US Army Corps
of Engineers
Fort Worth District

RIVERSIDE OXBOW
Upper Trinity River
Fort Worth, Texas

INTERIM FEASIBILITY REPORT
AND
INTEGRATE ENVIRONMENTAL ASSESSMENT

April 2003

in cooperation with
Tarrant Regional Water District

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AND
INTEGRATED ENVIRONMENTAL ASSESSMENT

FOR

RIVERSIDE OXBOW
UPPER TRINITY RIVER
FORT WORTH, TEXAS

April 2003

Prepared by

U.S. ARMY CORPS OF ENGINEERS
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P.O. BOX 17300
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in cooperation with the

TARRANT REGIONAL WATER DISTRICT

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NOTE: Asterisks (*) represent those items required for compliance with the National Environmental Policy Act (NEPA).

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RIVERSIDE OXBOW
FORT WORTH, TEXAS

CHAPTER 1
INTRODUCTION

This report provides an overview of the status of the Riverside Oxbow Ecosystem Restoration Interim Feasibility Study. The documentation presents the results of the investigations of existing conditions, identifies problems and opportunities within the study area; describes an array of alternative solutions for ecosystem restoration, recreation, and other allied purposes that were developed during the plan formulation process, details the evaluation and analysis of the alternatives, presents the results of the analyses, identifies a National Ecosystem Restoration plan, and identifies a recommended plan based on coordination with resource agencies and input from the local sponsor. In addition, information will be provided on the status of various technical components and documentation required for the feasibility report.

BACKGROUND

At the request of the Tarrant Regional Water District (TRWD) at a meeting of the Upper Trinity River Feasibility Study Flood Management Task Force on September 20, 1999, and with approval for modification of the Upper Trinity River Feasibility Cost Sharing Agreement (FCSA) during a meeting of the Upper Trinity River Feasibility Study Flood Management Executive Committee on September 24, 1999. The initial study effort was an Interim Feasibility study of the Clear Fork and West Fork of the Upper Trinity River Basin, Fort Worth, Texas. The study area for that broader investigation generally includes the 100-year floodplain of the Clear Fork and West Fork of the Trinity River from IH-820 in east Fort Worth to the Lake Worth Dam on the West Fork and the Lake Benbrook Dam on the Clear Fork. Site reconnaissance and documentation of existing conditions were completed for the overall study area in the fall of 2001, at which time the local sponsor expressed an interest in moving into plan formulation for a modified study segment - the Riverside Oxbow area. Per their request, this area has been identified for concentrated study effort. It is anticipated that the Riverside Oxbow interim feasibility study will be the first of several feasibility studies to be conducted during the next ten years to evaluate additional flood damage reduction and ecosystem restoration opportunities along the Clear Fork and West Fork in the Upper Trinity River Basin.

Study Authority. Authority for the Riverside Oxbow Ecosystem Restoration Interim Feasibility Study is contained in a resolution by the United States Senate Committee on Environment and Public Works dated April 22, 1988, as quoted below:

> *"Resolved by the Committee on Environment and Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors is hereby requested to*

review the report of the Chief of Engineers on the Trinity River and Tributaries, Texas, House Document No. 276, Eighty-Ninth Congress, and other pertinent reports, with a view to determining the advisability of modifying the recommendations contained therein, with particular reference to providing improvements in the interest of flood protection, environmental enhancement, water quality, recreation, and other allied purposes in the Upper Trinity River Basin with specific attention on the Dallas-Fort Worth Metroplex."

The legislative resolution defined the area of investigations as the Upper Trinity River Basin, with specific emphasis on the Dallas-Fort Worth Metroplex. A map for the Upper Trinity River Basin is shown in Figure 1 and a map depicting the overall Clear Fork and West Fork study area is shown in Figure 2.

Study Purpose. The purpose of the feasibility level investigations was to examine the water and related land resources problems along the West Fork of the Trinity River in the Riverside Oxbow region and identify restoration opportunities to more recent historic conditions. The goal of this study is to determine whether there is a need for flood damage reduction activities, whether there is potential to restore ecosystem quality and functions, and to identify solutions, if feasible, to restore aquatic, wetland, riparian forest, and bottomland communities within the study area to benefit all resident and migratory wildlife and aquatic species indigenous to the Trinity River riparian corridor. It is recognized that restoration of the fish and wildlife habitat which existed in the mid-1800's might not be possible; however, it is reasonable to expect to be able to restore and maintain the quantity and quality of wetland habitat that existed within more recent history. Another study goal is to identify opportunities to incorporate recreation, water quality, erosion control, and allied purposes to develop a multipurpose plan that optimizes the use of Federal funds within the public interest to the maximum extent possible.

Study Location. The Riverside Oxbow study area, which encompasses approximately 1060 acres, is located just east of downtown Fort Worth, Texas on the West Fork of the Trinity River. The study area's river reach lies downstream of Riverside Drive, the downstream end of the Fort Worth Floodway project, and generally extends to a point coinciding with the East 1st Street bridge crossing of the West Fork, a length of approximately 3.14 miles. The reach includes the old West Fork channel, which formed an oxbow when the channel was realigned, the West Fork and Sycamore Creek confluence, and a low water dam downstream of Beach Street. Currently, the upstream end of the oxbow is plugged with an earthen dike. Backwater from the West Fork enters the oxbow from the downstream end. In addition, the oxbow receives runoff drainage from the industrial/commercial area to the north.

Generally, the study area lands fall within I-30 on the south and the 100-year floodplain boundary to the north. In addition, the study area includes an approximate 160-acre tract of land located south of IH-30.

Figure 1 – Trinity River Basin Map

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Figure 2 - Clear Fork and West Fork Map

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STUDY PARTICIPANTS AND COORDINATION

The Project Delivery team (PDT) for this study is comprised of various planners, scientists, engineers, and other professionals from the Fort Worth District, and representatives from the city of Fort Worth, Streams and Valleys (S&V), and TRWD. The list of PDT members can be found in Table 1. Coordination has been maintained throughout the study with the local sponsor, state and local government officials, resource agencies, the news media, interested organizations, and citizens in the local study area. Existing flood plain information from Federal Emergency Management Agency studies of the city of Fort Worth and Tarrant County was utilized. Coordination with the U.S. Fish and Wildlife Service is on going in accordance with the Fish and Wildlife Coordination Act of 1958 (Public Law 85-624). USFWS participation includes preparation of a Coordination Act Report, which is included as an appendix to this report. The Texas State Historic Preservation Officer was informed of this study effort by letter April 9, 2002, which included a brief description of the status of cultural resource database searches and surveys for the study area. Similar contact was made with Texas Parks and Wildlife Department, the Texas Commission on Environmental Quality, and the Environmental Protection Agency, Region 6. The Texas State Department of Transportation was also contacted concerning bridge profiles and other available information. The city of Fort Worth and TRWD officials were contacted numerous times to obtain pertinent data, discuss findings of existing conditions surveys, help identify potential restoration opportunities discuss viable ecosystem restoration alternatives.

Table 1
Project Delivery Team Members

NAME	TECHNICAL SECTION	AGENCY
Gene Rice	Trinity River Account Manager	USACE
Marcia Hackett	Project Manager	USACE
Billy Colbert	Environmental Resources	USACE
Efren Martinez	Civil Design Engineering	USACE
Jeff Comer	Civil Design Engineering	USACE
Wayne Elliot	Environmental (HRTW) Investigations	USACE
Russ Hendricks	Real Estate	USACE
Mark Black	Geotechnical Engineering	USACE
Michael Danella	Hydrology and Hydraulic Engineering	USACE
Craig Loftin	Hydrology and Hydraulic Engineering	USACE
Jay Newman	Cultural Resources	USACE
Eric Irwin	Landscape Architecture	USACE
Valerie Sewell	Landscape Architecture	USACE
Dennis Akins	Geographic Information Systems	USACE
James Sears	Cost Engineering	USACE
Warren Shaver	Structural Engineering	USACE
Carol Hale	Fish and Wildlife Biologist	USFWS
Wayne Owen	Planning Manager	TRWD
Randall Harwood	Assistant Parks and Community Services Director	Fort Worth
Adelaide Leavens	Executive Director	S&V

PRIOR STUDIES AND PROJECTS

Numerous reports have been published which document prior studies performed on various portions of the Clear Fork and West Fork of the Trinity River. In many cases, these studies have resulted in implementation and/or construction of projects by USACE, other Federal agencies, and local interests. The following paragraphs describe prior studies and projects within the vicinity of the Riverside Oxbow study area.

U.S. ARMY CORPS OF ENGINEERS STUDIES AND PROJECTS

Specifically Authorized Projects. Most studies performed by the USACE have historically been managed under the General Investigations (GI) program. Projects under this program must be specifically authorized and funded by Congress to meet a specific purpose or purposes. These specific project purposes include flood damage reduction, ecosystem restoration, water supply and conservation, recreation, and other allied benefits. The following is a list of the GI studies and/or projects that have been conducted or authorized.

Fort Worth Floodway. The Fort Worth Floodway was authorized by Section 2 of Public Law No. 14, 79th Congress, 2nd Session approved March 2, 1945. The project, which was completed in September 1957, basically entailed the construction and/or strengthening of levees and the widening and straightening of the Clear Fork channel from Lancaster Street to its confluence with the West Fork, the construction and/or strengthening of levees and widening and straightening of the West Fork channel from White Settlement Road to Riverside Drive, and the construction of levees in the upper reaches of the West Fork in the Crestwood and Brookside neighborhoods, along with allied features including removal of timber and debris from the floodway, reconstruction and alteration of bridges and public utilities to conform to the proposed channel and floodway, re-alignment of roads crossing the floodway, changing channel diversion and drainage structures in accordance with design analyses, and construction of new interior drainage structures, where necessary. Figure 3 displays the Riverside Oxbow study area in relationship to the Fort Worth Floodway and subsequent extensions.

Fort Worth Floodway Extension, West Fork. The Flood Control Act of 1960 provided for an extension upstream of the completed Fort Worth Floodway Project. The project is located on the West Fork of the Trinity River from White Settlement Road upstream to just downstream of Meandering Road and consists of improvement of 4.1 miles of river channel, construction of 6.2 miles of levee, appurtenant drainage facilities, and 1.6 miles of diversion channels. Construction was initiated in March 1965 and completed in June 1971.

Fort Worth Floodway Extension, Clear Fork. The project, authorized by the Flood Control Act dated October 23, 1962, is located along the Clear Fork of the Trinity River between the existing Fort Worth Floodway, as described above, and State Highway (SH) 183, also known as Southwest Boulevard. The extension comprised channel improvement of a 6.5-mile stretch of the Clear Fork, along with construction of 2.3 miles of

Figure 3 - Study Map Showing Upstream Federal Projects

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levee, provision of interior drainage facilities consisting of three sump areas, gate-controlled sluices, and 1.0 miles of diversion channels and appurtenant works, alteration of highway and railroad bridges, as necessary, relocation and alteration of three channel dams, and control of about 566 acres of rights-of-way. Construction of the project was initiated in January 1966 and competed in September 1971.

Upper Trinity River Basin, Trinity River, Texas – Reconnaissance Report. This report was completed in March 1990 and serves as the Reconnaissance Study phase investigation for the current study. The study was requested by thirteen sponsors, including nine municipalities, three counties, and the Tarrant County Water Control and Improvement District No. 1, now known as the Tarrant Region Water District, under the authority of a Senate Resolution adopted April 22, 1988. The emphasis of the legislation was *"...to provide improvements in the interest of flood protection, environmental enhancement, water quality, recreation, and other allied purposes in the Upper Trinity River Basin."*

Major flooding events occurred in the Upper Trinity River Basin study area in October 1981, May 1989, and June of 1990. During the flood events, the need became apparent for additional flood protection for the Dallas-Fort Worth Metroplex area. Conservations with officials, documented newspaper articles, and the analyses conducted during the Reconnaissance Study revealed the extent and areas of major flooding problems. Results of analyses indicated that all of the existing USACE projects were designed using criteria applicable to the time of their construction. However, it was discovered that urban development had exceeded previously projected expectations, causing increasing rainfall runoff. Additionally, spillway modifications made for dam safety purposes to Lake Bridgeport and Eagle Mountain Lake (non-Federal water supply lakes) had served to effectively reduce the level of protection provided by the existing Corps levee projects located downstream. Based on thirteen structural alternatives investigated and the social and environmental impacts of each of the alternatives, eleven viable flood control projects were identified.

Other water and land resource problems and needs identified during the study were water quality improvement, environmental and fish and wildlife enhancement, recreational development, and the need for preservation of open space with the Dallas-Fort Worth Metroplex area.

Upper Trinity River Basin - Texas Information Paper, "A Benefit-Cost Analysis." The report, dated February 1995, was prepared jointly by the USACE and the North Central Texas Council of Governments (NCTCOG). The report is an information document that summarizes the feasibility level investigations performed by USACE, to identify water and related land resource needs within the Upper Trinity River Basin, under the authority of a Senate Resolution adopted on April 22, 1988. The impetus for the study was largely due to the findings given in the USACE report titled *Final Regional Environmental Impact Statement, Trinity River and Tributaries* (REIS). Two major conclusions presented in the REIS were: 1) a widespread lack of Standard Project Flood (SPF) protection currently exists and 2) existing USACE and local community permitting strategies have significant impacts on the extent of increase of this lack of SPF protection. The document is

organized so that summary details on the measures investigated for each entity (city, county, and special district) are organized chronologically as Flood Control, Water Quality, Recreation, and Environmental Enhancement/Restoration.

Upper Trinity River Basin - Final Programmatic Environmental Impact Statement. This report, dated June 2000, focuses on various potential USACE projects that were being investigated at the time as part of the Upper Trinity River Feasibility Study. Reasonably foreseeable projects being pursued by other entities were also identified within the study area and potential direct and cumulative impacts resulting from implementation of the potential USACE and other entities' projects on the human and natural environment were assessed. The document provides a general description of the affected environment of the Upper Trinity River Basin, which encompasses the Clear Fork and West Fork watersheds. In addition, the document identifies regional land cover changes and trends during the past 20 years. The document also analyses recreation use trends and make projections for future recreational needs in the Upper Trinity River Basin.

U.S. Army Corps of Engineers Reservoir Projects. Several USACE reservoirs have been authorized and constructed in the Upper Trinity River Basin. The reservoir projects are Ray Roberts Lake and Lewisville Lake located on the Elm Fork of the Trinity River; Grapevine Lake located on Denton Creek, a tributary of the Elm Fork; Joe Pool Lake on Mountain Creek, a tributary of the West Fork of the Trinity about 10 miles southwest of Dallas; and Benbrook Lake, which is located on the Clear Fork of the Trinity River.

Benbrook Lake. The Benbrook Lake dam is located approximately 10 miles southwest of downtown Fort Worth on the Clear Fork of the Trinity River in Tarrant County, Texas. The dam is a rolled earthfill type with a maximum height of 130 feet and top width of 28 feet. The dam controls a total drainage of approximately 430 square miles. At conservation pool elevation the lake covers a surface area of 3,770 acres. The project was authorized by the Rivers and Harbors Act of 1945 for flood control and water conservation and has been operational since the date of impoundment, September 29, 1952.

STUDIES AND PROJECTS OF OTHERS IN THE STUDY AREA

Riverside Drive Levee. In the early 1970's, the TRWD constructed a low levee in the north overbank, from Riverside Drive upstream to the Railtran Line bridge (old CRI&P lines). The levee is part of the flood control system and is approximately 8 to 12 feet in height with a crown width of about 14 feet and a length of approximately 1 mile. According to the hydrology and hydraulics modeling that was done as part of the Riverside Oxbow study, it has been determined that the levee currently provides protection for approximately a 30-year flood event.

Beach Street Dam. The project consists of a low water dam located downstream of Beach Street, which was recently completed under contract to TRWD. The dam was constructed within the West Fork River channel approximately 750 feet downstream of Beach Street, just upstream of the confluence of the Riverside oxbow with the West Fork. According to TRWD, at normal elevation the impoundment will cover

approximately 56.6 surface acres and contain 340 acre-feet of water. The work also entailed removal of 264,000 cubic yards of silt and gravel from the improved channel and laying back the banks of the channel in order to meet the valley storage criteria for approval under Corridor Development Certification (CDC) requirements.

Eagle Mountain Lake. Eagle Mountain Lake was authorization by the State of Texas under permit number 1074, which was issued May 1, 1928, with a priority date of July 13, 1925. The project is located on the West Fork of the Trinity River, 14 miles northwest of Fort Worth. The dam is composed of two sections of earthfill and a concrete spillway by high ground of Eagle Mountain and Burgess Gap. The structure is 4800 feet in length, 85 feet at its highest point and has a top width of 25 feet. Construction started January 23, 1930, with impoundment coming February 28, 1934. The local sponsor for the project was Tarrant County Water Control and Improvement District No. 1, now known as the Tarrant Regional Water District.

Lake Worth. Lake Worth was authorization from the State of Texas by certified filing No. 757 on June 27, 1914. The location of the project is on the West Fork of the Trinity River, in northwest Fort Worth. The dam is earthfill with a concrete spillway. The length of the structure is 3200 feet, with a maximum height of 50 feet and the top width varying to 40 feet. Originally this dam controlled a total drainage area of 2064 square miles, but with the construction of Eagle Mountain Lake just a few miles upstream, the drainage area was reduced considerably. Construction on the reservoir started in 1912 and the dam was completed in October of 1914. The city of Fort Worth was the local sponsor for the project.

NATIONAL ENVIRONMENTAL POLICY ACT REQUIREMENTS

The National Environmental Policy Act of 1969 (NEPA), as amended, is the nation's charter for environmental protection. NEPA establishes policy, sets goals, and provides means for carrying out the policy. Section 102 (2) of the Act includes a provision to prepare an Environmental Assessment (EA) on the effects of the proposed Federal action. The Federal regulations for implementing the procedural provisions of NEPA were published by the Council on Environmental Quality (CEQ) in the Code of Federal Regulations (CFR) as 40 CFR Parts 1500-1508 (43 Federal Register 55978-56007, November 29, 1978).

USACE regulations (ER 200-2-2, dated March 4, 1988, Procedures for Implementing NEPA) permit an EA to be a self-standing document or an integration of NEPA required discussions in the text of the report. Given the environmental nature of the Riverside Oxbow, Fort Worth, Texas study and in the interest of reducing paperwork, costs, and redundancies, the USACE elected to integrate these documents. Sections in this integrated report that include NEPA required discussions are marked with an asterisk in the Table of Contents to assist readers in identifying such material. The document addresses the alternatives investigated and the respective environmental effects for Riverside Oxbow, Fort Worth.

A Programmatic Environmental Impact Statement (PEIS) was completed in June 2000 that addressed cumulative impacts of potential Corps of Engineers projects and projects of others in the Upper Trinity River Basin. This proposed Riverside Oxbow project, to the extent that it was defined at that time, was addressed in the PEIS. The Environmental Assessment integrated into this report is tiered to the PEIS and the direct and cumulative impact assessments included in the PEIS are incorporated by reference. Site-specific resources and impacts are addressed in the Riverside Oxbow integrated report. Cumulative impacts were also further discussed in relation to identified reasonably foreseeable activities in the Riverside Oxbow Study area. Because the impacts of the proposed Riverside Oxbow project, both direct and cumulative, are minor in scope and beneficial in nature, it is anticipated that a finding of no significant impact will be warranted. Because of the nature of the project, an EIS is not anticipated and this integrated EA, tiered off the PEIS, will undergo a single public review period.

POLICES RELATED TO FLOODPLAIN DEVELOPMENT

There have been two major regional policies developed since the mid-1980s that are specifically intended to reduce cumulative impacts to hydrology and hydraulics with the Upper Trinity River Basin.

Trinity Regional Environmental Impact Statement. The Trinity Regional Environmental Impact Statement (TREIS) was prepared by the USACE in the mid-1980s to address extensive floodplain development that was occurring along the Trinity River within the region. The TREIS focused on actions requiring permits under Section 10 of the River and Harbors Act of 1899 and Section 404 of the Clean Water Act of 1972, as amended, with emphasis on addressing cumulative impacts of granting multiple permits.

The Record of Decision (ROD) for the TREIS was signed in 1988. The ROD applies to all project actions requiring a permit under either Section 10 or Section 404 within the Standard Project Flood (SPF) floodplain. In general the criteria developed to reduce hydraulic impacts include the provision for no rise in the 100-year flood or SPF water surface elevations from dredging and/or fill activities along the mainstem, West Fork, and Elm Fork and tributaries with drainage areas in excess of 100 square miles. The criteria require a maximum loss in storage capacity for the 100-year flood and SPF of 0 percent and 5 percent, respectively, within the same area. For projects proposed on tributaries with drainage areas of 100 square miles or less, criteria allow for up to 15 percent reduction of valley storage within the 100-year floodplain and up to 20 percent reduction of the SPF floodplain valley storage. Requested projects on tributaries that would increase water surface elevations to a point of inducing additional flooding or damage to others are not to be permitted. The ROD also established guidelines for mitigation of environmental habitat losses caused by projects in floodplain areas covered by the TREIS.

The criteria of the TREIS ROD apply only to navigable waters under Section 10 and jurisdictional waters and wetlands of the United States under Section 404. It does not apply to projects for which the USACE has no regulatory authority. The TREIS raised awareness that a large area of floodplain lands within the Upper Trinity River Basin could be developed

outside the jurisdiction of the USACE and that if developed following only Federal Emergency Management Agency (FEMA) requirements, significant increases in flooding frequency and extent would continue to occur in adjacent and downstream areas. Subsequently, the Corridor Development Certificate process was established as a means to address those floodplain actions that were not within the jurisdictional areas administered by the USACE.

Corridor Development Certificate. The Corridor Development Certificate (CDC) program is a joint effort of the North Central Texas Council of Governments (NCTCOG), the U.S. Army Corps of Engineers, Fort Worth District, and member NCTCOG cities with jurisdiction over the Trinity River floodplain. The purpose of the CDC process is to affirm local government authority over for local floodplain management while establishing a common set of permit criteria and procedures for development within the Trinity River Corridor. The CDC process ensures that a proposed development's effect on future flooding will be considered in floodplain permitting decisions. Member cities, counties, and the NCTCOG administer the CDC program with technical advise by the USACE. The program, as part of the Trinity River Common Vision, relies on member cities within the area to require developers to submit plans showing the impact of their proposed projects on floodplain hydraulic values. Emphasis is placed on preservation of valley storage; however, projects with valley storage losses may be approved by participating cities when shown to be in the best overall public interest. After a review by all other cities within the CDC, the proponent city decides on whether to allow the floodplain alteration. The CDC criteria centers on stabilizing flood risk by not allowing new development to cumulatively worsen hydrologic and hydraulic impacts. The member cities participating in the CDC program include Arlington, Carrollton, Coppell, Dallas, Farmers Branch, Fort Worth, Grand Prairie, Irving and Lewisville.

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RIVERSIDE OXBOW
FORT WORTH, TEXAS

CHAPTER 2
STUDY AREA DESCRIPTION
EXISTING AND FUTURE CONDITIONS

This first section in this chapter describes the study area from a broad perspective, the Upper Trinity River watershed in Tarrant County. The material discussed includes information ranging from the general terrain and climate of the study area to a summary of the employment and economic status of the area. The next section of the chapter narrows the focus of discussion to existing conditions for the lands within the study area boundaries.

UPPER TRINTIY RIVER BASIN – TARRANT COUNTY

EXISTING CONDITIONS

General Description. The Upper Trinity River has been considerably urbanized. It is significantly influenced by the amount of water it receives from watershed runoff, overflows from surrounding man-made reservoirs, and the controlled discharges from sewage treatment plants. The combined effects of urban development and flood control activities within the basin have permanently altered the river's hydroperiod and pre-settlement hydrologic and hydraulic conditions.

The Clear Fork and West Fork study area is located within a highly developed metropolitan area, leaving the floodplain areas adjacent to the river of major environmental concern. Several flood control projects have been constructed in the Clear Fork and West Fork study area. The Fort Worth Floodway is located immediately upstream of the Riverside Oxbow study area. In addition, water supply and flood control reservoirs have been constructed upstream on both the Clear Fork (Benbrook Lake) and the West Fork (Lake Worth and Eagle Mountain Lake). The environmental characteristics within this area were significantly modified by these projects' construction and implementation and subsequent development and flood damage reduction activities.

Climate. The climate of Tarrant County is humid with hot summers and mild winters. The climate can also be characterized as continental with a wide range in annual temperature extremes. The average winter temperature is 48 degrees Fahrenheit (^{O}F) and the average summer temperature is 84^{O}F. Mid-afternoon relative humidity is approximately 55 percent. In the winter, temperatures can suddenly drop due to the influx of modified polar air masses, but such episodes are of relatively short duration. Tropical maritime air masses from the Gulf of Mexico tend to dominate the climate of the region during the spring, summer, and fall. Total annual precipitation averages 36 inches, with 57 percent of rainfall occurring between April and September. This coincides with the growing season for

most crops in the area. Thunderstorms are common in the spring and occur approximately 40 days per year (Natural Resources Conservation Service, 1980).

Geology and Soils. Most of Tarrant County is located in the Coastal Plain Province and is underlain with nearly horizontal beds of hard limestone and shale of marine origin from the Fredericksburg and Washita groups of Cretaceous Age. Geological units present include Quaternary floodplain and terrace deposits near the surface, consisting of clays, sands, and gravels.

According to the *Soil Survey of Tarrant County* (U.S. Department of Agriculture et al. 1981), the soils in the Clear Fork and West Fork study area are generally Frio silty clay. This deep, nearly level, clayey soil is on floodplains of major streams. The soil is well drained with moderately permeability and slow surface runoff. The hazard of flooding is considered the main limitation of this soil for urban uses. The exception to the Frio soil type in the study area is the soils in the Tandy Hills area, which are comprised of the Aledo-Bolar-Sanger association. Generally, these are shallow, very shallow and moderately deep, gently sloping, sloping, and moderately sloping clay and loamy soils that are well drained with moderate permeability and medium to rapid surface runoff. During a soil survey of Tarrant County, Texas, in June 1981, the NRCS indicated that these soils are moderately suited to most urban uses. The main limitations of these soil types are depth to bedrock, slope, and seepage during the wet seasons. For development purposes the rock layer limits the amount of grading and leveling that can be easily done.

Hydraulics and Hydrology. As noted in Chapter 1, the study area is within the region covered by two major floodplain management policies, the ROD of 1988 and the CDC program. Therefore, the baseline conditions hydraulic model used for this study is the current CDC model for the West Fork of the Trinity River. The CDC model was originally developed using the backwater program HEC-2 Water Surface Profiles. The model was subsequently converted to HEC-RAS River Analysis System version 3.0. The CDC manual and the CDC program affirm local government authority for local floodplain management while establishing a set of common permit criteria and procedures for development within the Trinity River Corridor.

The Trinity River Steering Committee, consisting of local elected official from jurisdictions in the Trinity River Corridor, approved the first edition of the CDC manual May 23,1991. Within the next two years, the participating communities (Arlington, Carrollton, Coppell, Dallas, Farmers Branch, Fort Worth, Grand Prairie, Irving, Lewisville) officially amended their floodplain ordinances to adopt the CDC common permitting criteria and process. In the CDC process, the CDC model is considered the design model for proposed development projects in the Trinity River Corridor. The CDC model was developed as part of the Upper Trinity River Feasibility Study. The CDC model is the design model used for analysis of proposed floodplain development projects within the Upper Trinity River Corridor.

The original CDC West Fork hydraulic models were developed by extensive use of digitized 2-foot contour interval topography. The topographic data was developed from February/March 1991 aerial photography. The majority of the cross-section data was

supplied by the surveying contractor and generated from the topographic data, with cross-sections locations developed by the U.S. Army Corps of Engineers. Additional cross-sections were developed in-house from the topographic files and included in the models as necessary. Other information used in the development of the models originated from bridge plans, bridge surveys, field reconnaissance, and levee surveys. Channel data originated from 1975 field surveys. Aerial photographs and field reconnaissance were used to determine roughness coefficients. The West Fork Trinity River CDC model limits are the confluence of the West Fork and the Elm Fork in Dallas County on the downstream side and the confluence to Lake Worth Dam on the upstream side, a distance of 58.08 miles.

The location of the Riverside Oxbow study area downstream of the Fort Worth Floodway and within the region covered by the ROD and the CDC process results in a set of criteria that must be followed for any proposed project design that impacts lands within the floodplain. These criteria include: 1) no rise in the design flood water surface profile (SPF) is allowed (USACE); 2) no rise in the Base Flood Elevation (BFE) 100-year flood (Federal Emergency Management Agency); 3) conditions outlined in the CDC process must be met; 4) Section 404 Record of Decision (ROD) which establishes hydrologic and hydraulic criteria for projects within the Trinity River floodplain in the Dallas-Fort Worth area, including no rise in water surface profile, no loss of valley storage, zero percent loss of valley storage in the 100-year event and no more than a maximum of five percent valley storage loss for the SPF event. Applicable mitigation for water surface increases and valley storage loss may be necessary and would be incorporated into detailed project design.

Water Quality. The Trinity River reach that flows through the study area is designated by the Texas Commission on Environmental Quality (TCEQ) Segment 806, the limits of which are identified as a point immediately upstream of the confluence of Village Creek with the West Fork in Tarrant County to Lake Worth Dam in Tarrant County. While the water quality of the Trinity River generally continues to improve, a few areas of concern remain in this segment. According to the State of Texas Clean Water Act Section 303(d) List (Draft 2002 305(b) Assessment), the lower 22 miles of this segment are impaired for fish consumption use and identified as a segment of concern for excessive algal growth. The assessment also noted that this segment was on the 2000 303(d) list for impairment due to bacteria, and because there were insufficient data to evaluate changes in water quality, this segment will be included on the 2002 303(d) list for bacteria. According to the latest round of tests conducted every two years by the TCEQ, PCBs and chlordane were found in the tissue of fish collected in this section and a Chlorophyll A assessment method indicated some concerns about the excessive amount of algal growth. The final results of the assessment summary state that aquatic life, public water supply, and general uses were fully supported for Segment 806 and contact recreation use was not assessed. The lower 22-mile section of Segment 806 includes the reach of the West Fork that flows through our study area. In fact, two of the monitoring sites for the lower 22 miles section of Segment 806 used during the recent testing were Riverside Drive and Beach Street in Fort Worth.

Air Quality. The study area is located within the Environmental Protection Agency's Air Quality Control Region (AQCR) 215 for Texas. AQCR 215 consists of 19 counties including Dallas, Denton and Tarrant counties. AQCR 215 is classified as a non-attainment area for ozone and attainment/unclassifiable for other National Ambient Air

Quality Standards including lead, sulfur dioxide, nitrogen dioxide, carbon monoxide, and particulates (40 Code of Federal Regulations 52.2308(a)).

Terrestrial Resources. Tarrant County is situated primarily in the Cross Timbers and Prairies region (Correll and Johnston 1970; Gould 1975). The Cross Timbers and Prairies vegetative region, named for the closely associated prairie and woodland vegetation, extends south from the Red River to Austin, a distance of approximately 250 miles. Distinct changes in the vegetation cover of this region are associated with differences in soils and topography. This region is generally characterized by level to gently rolling and hilly limestone country with extensive shallow or gravelly soils and some areas of deep clay soils. Original plant cover was mid- to tall-grass prairie broken by wooded drainages and rock outcrops.

The Riverside Oxbow study area is located within the Fort Worth Prairie vegetational zone. The Fort Worth Prairie and the Lampasas Cut Plain are prairie components that together make up the Grand Prairie, which is the designated prairie in the Cross Timbers and Prairies region. According to Diggs et. al (1999) in Shiner's and Mahler's Illustrated Flora of North Central Texas, the presettlement condition of the Grand Prairie was largely a vast grassland, with wood vegetation generally limited to the areas along major watercourses, as scattered mottes on hilltops, or associated with mesas and buttes.

Vegetation. The predominate grass species for the Cross Timbers and Prairies vegetative region include little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), and sideoats grama (*Bouteloua curtipendula*) (Gould 1975). Under natural conditions, tree species in the Cross Timbers and Prairies region include post oak (*Quercus stellata*), blackjack oak (Q. *marilandica*), and hackberry (*Celtis ssp.*).

Wildlife. Historically, the river channels, riparian corridors, and wetlands associated with floodplains of the Trinity River supported a variety of wildlife species for cover, food, and nesting areas. Bird species commonly found in these areas included a wide variety of migratory songbirds and waterfowl, raptors such as the red-tailed hawk and American kestrel, and wading and shore birds such as herons and egrets. Amphibians, reptiles, and mammals common to these areas included frogs and toads, snakes, turtles, cottontail rabbits, cotton rats, field mice, opossum, raccoons, bobcats, beaver and coyotes.

Aquatic Resources. The Clear Fork and West Fork of the Trinity River, along with their associated tributaries and constructed reservoirs are the main water bodies in Tarrant County, in addition to some existing ponds and wetlands within the floodplain. However, due to the altered hydroperiod caused by construction and implementation of the reservoirs and major flood control projects, most of these smaller floodplain ponds and wetlands associated with the streams are dependent upon rainfall runoff for their water supply. In the long, hot Texas summers, many of these small bodies of water are either significantly reduced in size or dry up completely.

In certain areas, the river channel has a variety of aquatic resources, i.e. riffles, runs, and pools, which provide habitat for several species of invertebrates and fish. Studies conducted by Texas Parks and Wildlife Department, the University of North Texas' Institute of Applied Sciences and University of Dallas (Dickson et. al. 1989), identified 12 families and 46 species of fish within the Upper Trinity River Basin, which includes the Clear Fork and West Fork. These studies verified that stream fisheries have improved since the 1970's and early 1980's, due primarily to improved water quality resulting from improved wastewater treatment. Sport fish present in the study area include largemouth bass, channel catfish, crappie, and white bass. Other species which tend to be more tolerant of moderate levels of nutrients and lower dissolved oxygen content in the area include common carp, river carpsucker, longnose gar, freshwater drum, several species of shiners, and bullhead catfish. Non-sport fish species found in the study area that are less tolerant to pollutants include gizzard shad, mosquito fish, and several sunfish species.

One of the major factors limiting the quality and diversity of the aquatic habitat along and in the river channel in the overall Clear Fork and West Fork study area is the lack of edge and instream vegetation and structure. This type of vegetation and structure would serve to provide food sources, shade, cover, and reproduction sites for multiple aquatic species, including invertebrates, and fish, in addition to waterfowl, and shore and wading bird species.

The wetlands and open water ponds found in the floodplain adjacent to the river generally support the same types of aquatic invertebrates and fish species as the river channel. While the wetland areas provide emergent vegetation and other physical habitat that is generally lacking in the river and most of the open water ponds, the altered hydrologic regime of the floodplain as a result of flood protection reservoirs and channelization projects upstream allows for only occasional overbank flows. These wetland areas often do not retain water throughout the year, but dry up during the long, hot summer months, thus reducing their aquatic habitat value. In addition, because of the reduced frequency of overbank flooding, these wetlands no longer function effectively within the watershed as reproductive and nursery sites for multiple species of invertebrates and fish. For these reasons, the overall diversity of the aquatic invertebrate and fish species within the Clear Fork and West Fork watershed remains relatively low.

Recreational, Scenic and Aesthetic Resources. The 1990 Texas Outdoor Recreation Plan (TORP), prepared by the TPWD, identifies existing recreational facilities, usage trends, and projected recreational needs for 23 regions within the state. The study area is within a 16-county area designated in the TORP as Region 4.

Region 4 has experienced several years of rapid growth. With approximately 350 people per square mile, the density of Region 4 is surpassed only by the Houston region. Many of the small towns and rural areas in Region 4 have become part of the rapidly expanding metropolitan area as people have moved from the heavily populated cities to the suburbs. People in these urbanizing areas are finding open space increasingly scarce. The region now ranks twenty-first out of 23 regions in recreation land per thousands population.

Residents of the Metroplex need not drive far to find recreational waters because many of the state's major reservoirs are located in the metropolitan area. A total of 232,581 surface acres gives the region more lake acres than all regions except Deep East Texas; however, the large numbers of people residing in the region make the suitable surface acres per thousands population still fall far below the state average.

With so many reservoirs in the area, the value of the free-flowing sections of the region's rivers increases as they become more rare. Public agencies within Region 4 are taking a fresh look at the valuable resources within their jurisdictions, which are highly desirable for recreation. Sites within the Trinity River floodplain are among those most actively studied. Nine cities and three counties within the region, including Tarrant County, are participating with the North Central Texas Council of Governments in development of a *Common Vision* to protect resources within this corridor. Goals include the development of a regional construction permit system and cooperation in the creation of a linear greenbelt of parks and trials along and adjacent to the river and its tributaries.

The most scenic wooded areas in Region 4 are often found in the stream and river corridors. Scenic corridors along the Trinity River, with natural meandering water courses bordered by riparian hardwoods or dense stands of trees and shrubs, are the most desirable segments of the river and the portions most intensely used by the recreating public. Recreation providers have expressed concern over stream bank erosion, in-stream flows, and the quality of the water for contract recreation. The Trinity River and its tributaries are currently being used for a variety of recreational activities, though access is limited or restricted. In spite of these limitations, avid canoeists, kayakers, fishermen, bicyclists and bird watchers have located points where parks areas, roads and bridges intersect with the river.

Socio-Economic Conditions. Tarrant County, with a population of 1,336,500 (estimated population as of January 1, 2001), has an economy centered on agricultural interests in the rural areas and the city of Fort Worth and its suburbs. Major Tarrant County employers include Burlington Northern, American Airlines/AMR, Alcon Laboratories, Lockheed Martin Corporation, Tandy Corporation and NAS Fort Worth Joint Reserve Base. It is anticipated that the region will continue to grow due to the influence of the increasing industry and employment opportunities and the relatively low housing and cost of living estimates.

The city of Fort Worth, with an estimated population of 542,504, serves as the county seat. According to *American Demographics,* April 1995, Fort Worth ranked eighth in the U.S. in projected population growth over the next ten years and 18th in employment growth. Fort Worth is a city whose economic base is diverse and expanding with companies involved in business activities ranging from cellular communications and semiconductor chip manufacturing to the defense and transportation industries.

RIVERSIDE OXBOW STUDY AREA

The study area, approximately 1060 acres in size, is located in the city limits of Fort Worth just east of the downtown area along approximately 3.14 river miles of the West Fork of the Trinity River. The upstream limit of the study boundary is Riverside Drive and the downstream limit is East 1st Street. The study area, which is located within a highly urbanized region, includes one of the largest contiguous tracts of undeveloped property within the city of Fort Worth. The major feature of the study area is a remnant of the original channel of the West Fork of the Trinity River that was separated from the river with the construction of a modified channel in the early 1970s. The resultant oxbow, which is approximately 1.58 river miles in length, collects water from local runoff and as backwater from the main river channel at its downstream confluence with the West Fork. Because of the size of the study area and differences in existing resources and possible ecosystem restoration opportunities, the study area was divided into zones to assist in the description of existing conditions and the evaluation process. The zones are Oxbow North, Oxbow Center, Oxbow South, Gateway Beach, Gateway Center, Gateway South, Gateway Park, Gateway East and Tandy Hills. Figure 4 displays the project zones and the limits of the 100-year floodplain within the study area.

The study team used several techniques to help identify, quantify and qualify existing conditions within the study area in order to projected future with- and without project conditions. These included but were not limited to:

- Site reconnaissance by a multiple disciplined, multi-agency group, including personnel from the USACE, TRWD, USFWS, TPWD, EPA, TRWD, and the city of Fort Worth Parks and Community Services
- Literature reviews
- Database searches
- Reviews of historic planning and plans and specification documents
- Reviews of prior and on-going permit actions
- Personal contacts with local utility companies
- Personal contacts and review of documents from various city of Fort Worth departments, such as the Water Department, Transportation and Public Works, Parks and Community Services, Real Property Management, Zoning and Platting
- Personal contact and review of documentation from the Tarrant County Tax Appraisal District
- Personal contact and review of documents from the Texas Department of Transportation
- Personal contacts with land owners within and adjacent to study area
- Series of public meetings held by TRWD, Streams and Valleys, and city of Fort Worth' Parks and Community Services personnel to solicit input and concerns from local citizens and interest groups about the river, Gateway Park, and the project area, etc.

EVALUATION AND ANALYSIS TECHNIQUES

The study team also employed satellite imagery to conduct vegetation classification for quantifying habitat types and habitat evaluation procedures to determine the quality of the existing habitat types.

Vegetative Cover Analysis. Satellite imagery used for this work effort were SPOT (French) satellite data acquired by USACE as part of a 1997 Interagency Agreement with the Environmental Protection Agency (EPA) to facilitate *Wetlands Study of Dallas-Ft. Worth Metroplex*. Two multi-spectral and two panchromatic (black and white) images were acquired to center on the Dallas County and Tarrant County within the Upper Trinity River study area. The four images date to late spring (April - June) 1996. The multi-spectral data is 20-meter resolution and the panchromatic is 10 meter. The data were classified in late 1997 by USACE for the Trinity River project into general landcover classes.

Image classification was conducted using ERDAS Imagine software. Unsupervised classification was done on the two multi-spectral scenes by grouping pixels in terms of multi-spectral characteristics using unsupervised (ISODATA) clustering methods to produce approximately 100 spectral classes for each image based on variability within the three multi-spectral bands. The classified images were then imported to GRASS GIS where they were each assessed against ground truth data (photos and fieldwork) to lump the 100 classes into about 12 general vegetation classes. The ground truth data used in the grouping of clusters included 1995 digital orthophotos, 1994 Landiscor hardcopy project orthophotos, existing ground truth field data collected by personnel from the USACE and USFWS, and limited field ground truthing trips. Some additional adjustment of classes was required to obtain a good edge match when the two files were merged into one vegetation map encompassing the two counties. The 12 general classes were further grouped to four categories that represent the most important types of vegetative cover within the study area.

Texas Parks and Wildlife Department, USACE, and USFWS personnel reassessed the accuracy of the classified image in the spring of 2001. With minor variations due primarily to slightly denser shrubbery and undergrowth, the land use had changed very little. The most significant variations were due to the fact that the images were collected during a dry period where areas of standing water and associated wetland type vegetation were smaller.

For the Riverside Oxbow study, all the classified images were transformed into ArcView shape files, each land use type being represented by a polygon. For analysis, the classified image was split into smaller polygons that corresponded to distinct areas of modified land use. Within each area of new land use, ArcView was used to determine the total land area of each present land use type. This information was used to identify the approximate acres and percentages of cover types for the different zones in the study area. The same breakdowns for the study area were used to project acre and land use changes anticipated with- and without-project conditions.

Figure 4. Study Area Zone Map

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Habitat Suitability Indices and Habitat Units. In order to identify and evaluate potential restoration opportunities, it is necessary to establish a baseline of current habitat values in the study area for comparison, therefore, an overall evaluation of the quality of the existing natural resources based on their value as wildlife, avian, and aquatic habitat was conducted. Evaluation procedures used were the Habitat Evaluation Procedures (HEP) developed by the USFWS. HEP utilizes various habitat characteristics within sample plots to numerically define the comparative value of habitat quality based on a 0 to1 scale, where 1 represents optimum habitat conditions and 0 represents habitat conditions of no usable value. HEP evaluates habitat based on Habitat Suitability Index (HSI) models for wildlife species that typify a targeted habitat type (i.e., bottomland hardwoods, grasslands, wetlands, etc.). For this study the indicator species used for evaluation of the grasslands were the red-tailed hawk, eastern cottontail, and eastern meadowlark. The species models used to assess the habitat value of the emergent wetland areas were the wood duck, raccoon, and green heron. Finally, the indicator species used to assess the value of the shrubland habitat types were the eastern cottontail, red-tailed hawk, raccoon, and scissor-tailed flycatcher. These species represent the various guilds associated with each habitat type. There was no specific aquatic habitat species model used in HEP evaluations for the Riverside Oxbow study area.

The HSI values represent the overall value that results from running an HSI model. Habitat units (HU) are derived by multiplying the overall HSI score from each habitat type by the number of acres of that habitat type in a given area. Because each of the study zones had more than one habitat type, values for each habitat type were evaluated and summed together for each study zone. Disturbed lands were assumed to have no usable value therefore assigned a value of zero.

Following are general descriptions of the existing conditions for the overall study area and then for each of the study zones specifically, including the number of acres of each habitat type along with the derived number of existing habitat units for each zone.

EXISTING CONDITIONS

General Description. Based on site visits by USACE, USFWS, and TPWD personnel, the study area contains several habitat and non-habitat land use types. A majority of the lands are grasslands, with most being manicured lawns, roadsides, dikes, constructed riverbanks, and parks consisting of bermudagrass (*Cynodon datylon*), St. Augustine grass (*Stenophrum secundatum*), and Johnson grass (*Sorghum halepense*). There are patches of native grasses that contain little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), sideoats grama (*Bouteloua curtipendula*), and Indiangrass (*Sorghastrum nutans*).

The existing woodlands are mainly located along the oxbow and the original West Fork channel downstream of the oxbow, but there is also a large tract of woodlands along drainages located south of IH-30. The predominant tree species are sugar hackberry (*Celtis laevigata*), cedar elm (*Ulmus crassifolia*), American elm (*Ulmus americana*), cottonwood (*Populus deltoides*), red mulberry (*Morus rubra*), and pecan, with common understory species

including common greenbrier (*Smilax spp.*), poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), ragweed (*Ambrosia trifida*), and immature hardwood tree species.

There are small areas of wetlands located within the 100-year floodplain in the study area. These wetlands are palustrine, which means that they are non-tidal wetlands dominated by trees, shrubs, and the presence of emergent wetland vegetation. Most of these wetlands are seasonal wetlands occurring in shallow depressions. The tree and shrub species in the forested wetlands are the same species found in the riparian woodlands. Figure 5 is an infrared aerial photograph taken in the mid-1990s that illustrates the various vegetational types in the area. The yellow line represents the study area boundaries.

Much of the study area has been highly impacted by human activities. The degree and extent of the changes in habitat have directly influenced the vegetation composition and numbers and species of wildlife found in the area. Proximity of a vast urbanized human population, past indiscriminate hunting, predator control, use of pesticides and various forms of air, water and land pollution have been responsible for declines in wildlife resources. Wildlife that remains live in a modified natural habitat within the immediate influence of an encroaching urban complex. Common wildlife species are those tolerant of man's activities such as squirrels, rabbits, migratory songbirds and various small rodents.

Following are general descriptions of the existing conditions found within the study area for each of the project zones. The acres of each habitat type identified represent the results of the vegetation analysis described above. The number of existing habitat units identified for each zone represents the compilation of the value of all the habitat types found in each zone utilizing the HEP analysis described above.

Oxbow North. The north oxbow area includes the cutoff oxbow channel between Riverside Drive and Beach Street, its associated riparian area, an adjacent ponded area just upstream of Beach Street, the lands around the ponded area, and a small parcel of land between Riverside Drive and the upstream end of the cutoff channel.

The area is 110.90 acres in size, with the majority being grasslands (68.92 acres). Existing forest covers 26.26 acres and water covers 1.68 acres. Wetlands, totaling 2.22 acres, were identified along the edges of the existing ponded areas and cutoff channel bottom. Disturbed soils, associated with heavy grazing by cattle and horses, totaling 11.85 acres was identified surrounding the ponded area. Based upon initial results from use of the USFWS HEP, this area was found to contain a combined total of 70.13 habitat units for the various habitat types under existing conditions. Industrial and residential developments immediately north of the area have caused direct and indirect adverse impacts. Runoff from the adjacent disturbed areas contains high silt loads and associated urban debris. The existing wooded corridor is narrow and composed primarily of non-mast bearing trees, such as cottonwood, willow, soapberry, and green ash. These trees, which are common to the Upper Trinity River system, have become established following previous disturbances of the original vegetation. Existing hard mast trees (pecan and bur oaks) are generally isolated on grasslands at distances up to 100 to 300 yards away from the channel. Photographs 1 and 2 show the oxbow channel and typical existing riparian vegetation.

The riparian channel along the upstream reach of the oxbow in this portion of the study area represents the first area of woodlands located downstream of the Clear Fork and West Fork of the Trinity River confluence. Beach Street, primarily because of its culverted underpass, presents a physical barrier to mammals, amphibians, reptiles and some bird species between the riparian resources associated with the Oxbow North reach and the riparian resources associated with the downstream segment of the oxbow and the West Fork of the Trinity River. The USFWS HEP procedures utilized in this study are based upon the assumption that quality of structure in the ecosystem is directly related to functional quality and production of environmental resources. The HEP models used for this analysis do not directly account for the disruptions in the functional value of the riparian habitat caused by Beach Street. Based upon professional judgment of the Corps of Engineers and U.S. Fish and Wildlife Service staff biologists, the HSI for the existing conditions of the riparian resources of the oxbow area was adjusted (weighted) to better reflect the adverse affect the lack of a bridge crossing has upon fish and wildlife resources. Results of the adjustment lowered the functional HSI value for existing forest stands in the Oxbow North zone from the initial 0.58 based on structure alone to 0.3. While not incorporated into the existing conditions computations, this adjusted value will be used in evaluating potential restoration opportunities for the zone, later in the plan formulation process.

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Figure 5. Aerial Photograph of Study Area

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The culverted crossing over the cutoff channel at Beach Street has a downstream invert that is several feet higher than the existing downstream water and ground surface elevations. In addition, the culvert serves as a barrier to movement of ground- and water-based species. Heavy traffic on Beach Street results in numerous road kills at the crossing. Photograph 3 and 4 shows the Beach Street culvert first from the upstream end and then from the downstream end looking back upstream.

Oxbow Center. This zone, as the name implies, lies between Oxbow North and Oxbow South. This zone is comprised of 124.53 acres of land. A review of old photographs reveal that the lands within this zone have apparently been used for truck farming in the past, but have been fallow for the past 3 to 4 years. A partial remnant channel of Sycamore Creek, formed following the construction of the modified channel of the West Fork adjacent to this area, holds local runoff for short periods of time each year providing a small seasonal wetland. The imagery used to classify vegetation did not detect the small wetland because it appears to be less than one acre in size. The lands in this zone are predominately grasslands (101.94 acres) and are currently being used to produce a single hay crop per year. The remaining 22.37 acres have been identified as disturbed lands, likely associated with internal roadbeds developed when the area was actively farmed. Currently, most of these roadbeds have become overgrown with grasses due to the lack of use; the exception is a road along the modified channel that is used by TRWD personnel for maintenance purposes. This zone also has several large individual pecan and bur oak trees scattered along the edges of the abandoned Sycamore Creek channel. The existing wildlife habitat value of this zone is 78.52 habitat units for all habitat types. Photographs 5 and 6 depict the large scattered mast trees and the existing grassland vegetation in the zone.

Oxbow South. The Oxbow South zone includes the area along the south and east banks of Sycamore Creek between IH-30 and the channel and a broader area between the modified channel and IH-30 extending from the west bank of Sycamore Creek to Riverside Drive. A parcel of land just west of Beach Street was not included in the study area within this zone because of the presence of a church. This zone also includes the confluence of Sycamore Creek with the modified channel, a low water dam downstream of Beach Street, and an existing 3.08-acre wetland. The most abundant terrestrial vegetation is grassland with dispersed wooded stands (29.46 acres). Disturbed areas cover an additional 1.47 acres. The existing wildlife value of the terrestrial and wetland habitat components of this site is approximately 24.23 habitat units. Photograph 7 shows the low water dam.

Gateway Center. This zone is located in the area immediately downstream of the Beach Street crossings of the improved channel and the remnant oxbow channel. It includes a triangular-shaped tract of land that contains the riparian zone along the south side of the oxbow and the north side of the improved channel. The zone consists of 27.31 acres of low quality woodlands and highly manicured grasslands with a total habitat quality of 6.73 habitat units. Specifically, this zone contains about 9.98 acres of existing forest, 9.22 acres of grassland and 7.6 acres of disturbed land associated with channel maintenance activities and a couple of old business sites, and less than half an acre each of water and wetlands. The location of the zone provides an important link between upstream resources and those associated with the riparian forest located downstream. Photographs 8 shows the business sites and buildings located in this zone.

Gateway South. This zone encompasses the Gateway Center zone both to the north and south across the oxbow channel and the modified channel. North of the oxbow, the zone generally includes the bottomland hardwood corridor located between Beach Street on the west, the park entrance road to Gateway Park on the north, and the first river bend below the confluence of the oxbow with the West Fork on the east. South of the modified channel the zone includes mostly grasslands from Beach Street on the west, the modified channel on the north, IH-30 on the south, and the first river bend below the confluence of the oxbow with the West Fork on the east. The zone, mainly consisting of grasslands, is about 45.93 acres in size. The grasslands make up about 25.33 acres. The riparian woodlands comprise 15.73 acres. Water and wetlands combined account for just over one acre with the remaining 3.45 acres being disturbed soils. This zone has linkages to Gateway Beach, Gateway East, and all components of the oxbow. Total existing habitat values in this zone were determined to be 12.33 habitat units.

Gateway Beach. This zone, located between Beach Street and Gateway Park and north of the park entrance road off of Beach, has been heavily disturbed by past activities. Approximately 160 acres in size, this zone is comprised of approximately 0.30 acres of open water, 1.90 acres of wetlands, 23.77 acres of woodlands, 86.90 acres of grassland, and 47.12 acres of disturbed soils. Total existing habitat value for this zone is calculated at 21.70 habitat units. Gravel and soil mining activities resulted in the creation of several ponds and wetlands, some of which were subsequently filled under Section 404 permit conditions issued in November 1987. In addition to filling some of the ponds and wetlands, the ground elevation in a portion of the zone was raised out of the 100-year floodplain. The filled portion of the zone has largely reestablished a grass cover; however, bermudagrass dominates the area. Although no pads or buildings have been constructed on the fill, future without project conditions indicate that little additional filling would be required to make the portion of the tract that fronts Beach Street a highly desirable location for commercial development. As mitigation for fill activities, a small wetland area was contoured to connect to one of the residual lakes and a little bank sloping was conducted to foster some moist soil development. These areas provided adequate mitigation for the past filling activities; however, substantial improvements could still be implemented to provide substantially greater fish and wildlife habitat benefits. Site reconnaissance noted that the large pond is supporting winter stopovers of teal, gadwall, and mallards numbering close to a hundred individuals. Some of the native vegetation around the edge of the ponds also supports red-winged blackbirds, cardinals, and other songbirds. Non-native shrubs have begun to proliferate around the higher banks of the lake and, left unchecked, will greatly reduce future wildlife habitat values. The water source for the larger lake appears to be local runoff and drainage from the residential and commercial neighborhoods to the north. A smaller lake located adjacent to the larger lake had no visible water during the first late winter site visit and only a slight amount after a 5-inch rainfall event in the area.

Gateway Park. This zone includes all the lands (257.09 acres) south of East 1st Street between Gateway Beach and Gateway East. This entire zone is encompassed

Photograph 1. Oxbow channel.

Photograph 2. Riparian vegetation along the oxbow channel.

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Photograph 3. Upstream end of oxbow culvert at Beach Street.

Photograph 4. Downstream end of oxbow culvert at Beach Street.

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Photograph 5. Scattered hard mast trees in Oxbow Center.

Photograph 6. Grassland vegetation in Oxbow Center before mowing.

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Photograph 7. Low water dam downstream of Beach Street.

Photograph 8. Buildings and business sites located in Gateway Center.

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within Gateway Park, a city of Fort Worth public park that includes existing recreation facilities, such as softball diamonds, soccer fields, hiking and biking paths, picnic areas with pavilions, etc. The majority of these lands, 120.09 acres, are maintained grasslands, with about 68.60 acres of woodlands and 68.40 acres of disturbed areas. It was determined the Gateway Park zone provides a combined 43.01 habitat units under existing conditions.

Gateway East. This study zone extends downstream of Gateway Center to the East 1st Street bridge. Added later during the plan formulation period, the zone was found to contain tracts of high quality riparian woodlands, tracts where the riparian corridor is very narrow and comprised of non-mast producing light seeded invader trees and shrubs, and a tract that has been severely degraded as a result of past use as drying beds for a waste water treatment processing plant. The entire east corridor contains 138.72 acres providing a combined 69.05 habitat units. This reach is more heavily wooded than other reaches in the study, containing 97.01 acres of riparian forest. The remainder of the site consists of 0.72 acres of water, 5.62 acres of wetlands, and 34.94 acres of grassland. Only 0.43 acres of disturbed soil was identified.

Access through the zone is relatively easy due to presence of a small, concrete recreation trail. The trail is narrow and its current use pattern does not appear to conflict with existing or potentially improved future wildlife uses. An early spring visit through this zone resulted in the observation of numerous chickadees, warblers, wrens, cardinals, crows, hawks, and other birds within the better quality woodlands. Another feature observed adjacent to the better quality woodlands was an old naturally occurring oxbow remnant that currently receives water from the West Fork of the Trinity River only during periods of high flows; in fact, nearly out of bank levels. The oxbow contained water during the site visit and debris and the direction of the lean of soft-stemmed vegetation indicated that the water had entered the oxbow through a channel located between the eastern end of the remnant oxbow and the West Fork. Fish and amphibians were observed utilizing the newly inundated areas in the bottom of the oxbow.

One other small body of water is located at the extreme northern end of the drying beds. While the original function of this area is unclear, it apparently fluctuates in depth over the course of the year. During the site visit, about 25 percent of the area was inundated. Stubble from mowing was visible in some of the inundated area and all of the non-inundated area. About a dozen teal and wood ducks were observed on this small lake. Although somewhat sheltered, the lack of forested vegetation to the north and the lack of tall grasses around the perimeter of the wet area likely limit the use of this area by waterfowl. The drying beds associated with the abandoned wastewater treatment facility are grown over with grasses and some young trees including willows, hackberry and boxelder.

Tandy. Of the 158.60 acres making up the Tandy zone, almost 59.87 acres are wooded with mixed grasslands and shrublands occupying most of the remaining area, or 90.27 acres. Vegetative cover imagery identified 7.71 acres of disturbed lands; however, it is believed that the amount of disturbed soils have more than doubled since the date the imagery was captured. Total existing habitat value of this study reach is 68.78 habitat units.

The eastern portion of this study zone contains all of Tandy Hills Park, an approximately 106-acre parcel of land owned by the city of Fort Worth and designated as parklands. The only recreational facility in this park is a small playground, less than 2 acres in size, located along View Street at the southern end of the property. In addition to the parklands, this zone includes approximately 53 acres of land west of the park. Most of these lands are in private ownership, with the majority being portions of long narrow residential tracts that run from Scott, Young, and View streets to the right-of-way of IH-30 to the north. The remaining tracts of land in this zone are located along Ben Street and are zoned for commercial use. The entire zone is unique within the study area due to the highly diverse terrain and the different vegetational compositions that result. These include a relic native prairie on the upper slopes which is being modified due to the invasion of woody species and human disturbances, particularly erosion problems on the privately owned lands to the west. Photograph 9 and 10 show the Tandy zone, including both the grasslands with invasive shrubs and the wooded riparian stands.

Prior to the construction of IH-30, this area was an integral component of the riparian and associated upland ecosystem of the West Fork of the Trinity River. The construction of the highway served to separate the bottomlands in this zone from the riparian corridor along the river channel to the north and, because the highway's bed was raised, removed the bottomlands from the 100-year floodplain. The area, which is located south of IH-30 across from Gateway East, contains numerous riparian fingers associated with narrow rivlets that now connect to the West Fork of the Trinity River through a series of culverts under the freeway. Grass species, mesquite, and eastern red cedar dominate the open plateaus with the low draws and drainages being dominated by woody shrub and tree species. Besides topography, the reason for the varied vegetation associations in this zone is due to the different soils that underlie the site – Aledo, Aledo-Bolar, and Frio soil types. Each of these soil types has a characteristic natural plant community.

The Aledo soil is situated on the upper shelves of high ground. The climax plant community should be a prairie of mid- and tall-grasses interspersed with an abundance of forbs (wildflowers). Historically, little bluestem would have made about 45 percent of the composition with Indiangrass, big bluestem, and switchgrass making up another 15 percent. Other common grasses would include sideoats grama, tall dropseed, slim tridens, silver bluestem, Texas cupgrass, hairy grama, buffalo grass, Texas wintergrass, and vine-mesquite. Forbs would be numerous and include purple paintbrush, Engleman daisy, prairie clover, Maximillian sunflower, heath aster, compass plant, golden dalea, penstemen, and gay feather. The presence of many of these species in association with one another indicate that this site is a relic of the Grand Prairie or Fort Worth Prairie that once covered much of the land in the region. Currently, the grasslands here are being invaded by woody shrub species, mesquite, and eastern red cedar.

The Aledo-Bolar soil is on the slopes. The Bolar soil climax plant community is true prairie consisting mainly of tall grasses, such as little bluestem, switchgrass, big bluestem and Indiangrass. Woody vegetation includes elm, hackberry, plum, live oak, aromatic sumac, New Jersey tea, and white honeysuckle.

Photograph 9. Grasslands with invasive shrubland vegetation.

Photograph 10. Grasslands with mesquite in foreground and riparian stringers along rivlets in background.

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The Frio soil occurs along the creeks and in the bottomlands of the zone. The climax plant community for the Frio soil is mid- and tall-grasses with a tree canopy of pecan, elm, bur oak, and cottonwood. Currently, there is an invasion of non-native woody species, such as privet, occurring on the slopes and in the understory of the bottomland hardwoods in this area. There are many wooded stands, especially in the eastern side of the Tandy zone where the only native vegetation to be found is the canopy trees. Photograph 11 shows the extent of the privet and other non-native vegetation in the understory of the bottomland hardwood stands.

An assessment of Tandy Hills Park conducted by representatives of the Fort Worth Nature Center and Refuge, part of the Fort Worth Parks and Community Services Department, indicates that in most of the areas where prairie still exists, the land is situated on slopes that were less desirable for livestock and unsuitable for farming. Examining aerial photos from the early 1940s indicate that the park was in excellent condition and, at that time, had less woody growth than similar areas nearby. Currently there appears to be more invasion of the grasslands from eastern red cedar, mesquite, and woody shrubs and a tremendous problem of non-native species, such as privets, invading the understory of the wooded sites. In the absence of corrective management, the native grasslands in this zone will eventually be converted to low quality woodlands.

While steps have been taken over the years to reduce disturbances to the Tandy zone, especially the parklands, there are still signs of erosion. Most of the erosion appears to be the result of illegal usage of the area by off road vehicles and random pedestrian hiking and biking trails that have damaged the vegetation that helps to stabilize the slopes. On the slopes and upland areas, these areas of damaged vegetation provide locations for runoff following rain events. This runoff washes additional soil and vegetation from the hills further exacerbating the problem and, over time, the soil on these slopes sloughs off and the problem magnifies (see Photograph 12). The existence of numerous riparian fingers with associated draws and rivlets in this zone that directly connect to the West Fork of the Trinity through a series of culverts under IH-30 mean that this soil quickly makes its way into the river causing increased sedimentation and turbidity and reducing the quality of the aquatic habitat. Photograph 13 depicts one of the narrow rivlets within the Tandy zone and photograph 14 shows the sedimentation that is occurring in the river channel just downstream of some of the culvert outfalls connecting the Tandy zone to the West Fork of the Trinity River. In addition to increasing sedimentation, the slope erosion and the encroachment of invader species in this zone, both in the understory vegetation of the bottomland hardwoods and in the native prairie grasslands, diminish the terrestrial wildlife habitat value of the area.

On the private land adjacent to Tandy Hills Park, the erosion damage has been much more severe. A restaurant, once located on top of a hill between the two areas, has been removed but considerable disturbance in the form of the slab, parking lots, and bulkheading to protect the foundation remains (see Photographs 15 and 16). Other slope alterations in the vicinity and trash dumping at the end of the cul-de-sac access have decreased habitat quality of the area. Photographs 17 and 18 show a large area of disturbance from what appears to be an attempt to make an access route, which has significantly impacted the vegetation in the western end of the zone. Erosion and the resulting sedimentation transport into the river

channel, the transportation of seed sources from the non-native invasive plant species, and the loss of habitat quality and diversity within this zone poises a significant threat to the other zones within the study area, and to the terrestrial and aquatic habitat of the lands along the West Fork downstream of the Tandy zone.

Existing Conditions Summarization of Acres and Habitat Units. Table 2 displays the total acres, the habitat units for each major habitat type, and the total habitat units for each project zone as determined during the existing conditions investigations.

Table 2
Summary of Acres and Habitat Units for Existing Conditions

Project Zone	Forested		Wetland		Grassland		Water		Disturbed	Total	
	Acres	HUs	Acres	HUs	Acres	HUs	Acres	HUs	Acres	HUs	Acres
Oxbow North	26.26	15.23	2.22	1.16	68.92	53.07	1.68	0.67	11.85	**70.13**	**110.93**
Oxbow Center	0.22	0.03	0.00	0.00	101.94	78.49	0.00	0.00	22.37	**78.52**	**124.53**
Oxbow South	0.29	0.16	3.08	1.60	29.17	22.46	0.00	0.00	1.47	**24.22**	**34.01**
Gateway Center	9.98	5.29	0.34	0.18	9.22	1.20	0.17	0.06	7.60	**6.73**	**27.31**
Gateway South	15.73	8.33	1.13	0.59	25.33	3.29	0.29	0.12	3.45	**12.33**	**45.93**
Gateway Beach	23.77	9.51	1.90	0.76	86.91	11.30	0.30	0.12	47.12	**21.69**	**160.00**
Gateway Park	68.60	27.40	0.00	0.00	120.09	15.61	0.00	0.00	68.40	**43.01**	**257.09**
Gateway East	97.01	62.09	5.62	2.13	34.94	4.54	0.72	0.29	0.43	**69.05**	**138.72**
Tandy	59.87	24.55	0.80	0.00	90.27	44.23	0.00	0.00	7.71	**68.78**	**158.65**
TOTALS	**301.73**	**152.59**	**15.09**	**6.42**	**566.79**	**234.19**	**3.16**	**1.26**	**170.40**	**394.46**	**1,057.17**

Aquatic Resources. The aquatic resources in and adjacent to the Riverside Oxbow study area include two low water dams constructed to hold more water at specific points along the river channel. These dams are the 4th Street dam located just upstream of the study area and the new Beach Street dam located within the study area river reach. During site reconnaissance for the existing conditions phase of this report, it was observed that one of the major limiting factors for aquatic habitat quality in the study area was the lack of vegetation along and overhanging the rivers edges. This overhanging and bank vegetation provides food sources, shade, cover, and reproduction sites for multiple numbers of aquatic species, including invertebrates, fish, waterfowl, and shore and wading bird species. Reconnecting old oxbows to the main channels and adding low flows through these old river meanders was identified by the study team as a way to improve the quality and quantity of

aquatic habitat in the area by providing this type of bank and overhanging vegetation without compromising flood flow functions designed for the main channels.

The river, ponds, and wetlands in the study area support a variety of aquatic species, but there is relatively little diversity in the aquatic invertebrates and fish species found. Within the river reach of the study area, concerns about the quality of the fishery habitat include turbidity, high temperatures, oxygen-demanding pollutants which interact to produce lower dissolved oxygen concentrations, excessive algal growth, and, according to recent testing by the TNRCC, the presence of PCBs and chlordane somewhere in the sediments which bioaccumulate in the tissue of fish. Physical habitat for fish is scarce, particularly in the channelized reaches within the Fort Worth Floodway upstream from the project area and in the improved channel from Riverside Drive to the low water dam below Beach Street.

The wetlands and open water ponds found in the floodplain adjacent to the river generally support the same types of aquatic invertebrates and fish species as the river channel. The wetland areas provide emergent vegetation and other physical habitat that is lacking in the river and most of the ponds; however, because of the altered water flow within the river as a result of flood protection reservoirs and channelization projects upstream which allow for only occasional overbank flows, these wetland areas generally do not hold water throughout the year, but often dry up during the long, hot summer months. For this reason, the diversity of the aquatic invertebrates remains low, as does the diversity of the fish species that the invertebrates support.

Threatened and Endangered Species. The following information indicates that a few federally protected species may occasionally migrate through the study area, but none are expected to utilize the habitat of the land parcel in question.

Table 3
Federally Listed Threatened And Endangered Species
Tarrant County, Texas
(Source U.S. Fish And Wildlife Service, 2002)

Common Name	Scientific Name	Listing Status
Bald eagle	*Haliaetus leucocephalus*	Threatened
Black-tailed prairie dog	*Cynomys ludovicianus*	*candidate for listing
Interior least tern	*Sterna antillarum*	Endangered
Whooping crane	*Grusamericana*	Endangered
*Mountain plover	*Charadrius montanus*	*proposed as threatened

Data from the Texas Parks and Wildlife Department (TPWD) and the U.S. Fish and Wildlife Service (USFWS) were used to determine the potential for the study area to support the presence of state and federally protected species and sensitive areas. According to the Texas Biological and Conservation Data System of TPWD, no occurrences of sensitive species or natural communities are known in the vicinity of the study area. The USFWS indicates that the area would be within the known range of three species including the threatened bald eagle, the endangered interior least tern and the whooping crane. In addition, the USFWS

noted that the area under study would also be within the known range of the mountain plover, a candidate that has been proposed for listing as a threatened species, and the black-tailed prairie dog, which is a candidate for listing as a protected species. However, according to the USFWS, there is no designated critical habitat for listed species in Tarrant County.

Cultural Resources. The study area has been inventoried for cultural resource properties. Results of a Phase I survey and geoarcheological work conducted in June and July of 2002 indicate the presence of one prehistoric site within the oxbow area. This large site consisting mostly of burned rock, animal bones and mussel shell is located in the southwest portion of the oxbow area along the remnant of Sycamore Creek. It is considered to be potentially eligible for the National Register of Historic Places.

The preliminary assessment, Phase I survey, and geoarcheological study indicate that the area near the improved channel has been previously disturbed by channelization and is not likely to contain intact archeological properties. The preliminary assessment also indicates that the study area consisting of the level flood plain area within the meander has been disturbed by agricultural use over several decades that would have likely disturbed any near surface sites. However, the old river meander margins are essentially intact and several areas were noted that would indicate alluvial surfaces have been formed historically across the area. The potential for buried prehistoric properties is high within the oxbow and adjacent to the unchannelized portions of the river. Deep testing was conducted in the area of the proposed wetland complex, lake, and drainage channel. One prehistoric site was found in the area proposed for the drainage channel and will require additional testing or avoidance in order to comply with relevant cultural resource law. Deep testing was also conducted to the south of the West Fork of the Trinity in an area that has been proposed for deep impacts. No archeological sites were identified in that area. If deep impacts are proposed for areas not currently under consideration, additional deep testing will be required.

The preliminary literature review indicated the presence of a historic property consisting of a named stables and racetrack from approximately 1893. No evidence of the historic property was identified by the Phase I survey. Additionally, no other surface sites were identified by the survey. A cultural resources report, to be included as an appendix to the feasibility report, will present the results of the cultural resources investigations.

Since there were no flood damages to structures identified in this area, it is not anticipated that any proposed restoration project would include residential buy-outs or removals. Because of this, no disproportionate impacts to minority or low-income populations are anticipated which would meet the criteria for consideration per the Executive Order (EO) on environmental justice.

Photograph 11. Invasive privet in understory in Tandy zone.

Photograph 12. Erosion from off road vehicle track following rain event.

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Photograph 13. Rivlet in Tandy zone.

Photograph 14. Sediment deposit in river channel downstream of culvert outfall.

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Photograph 15. Bulkheading and erosion on slope below restaurant slab.

Photograph 16. Part of restaurant slab, bulkheading, and disturbed areas.

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Photograph 17. Large disturbed site in western portion of Tandy zone in March.

Photograph 18. Same large disturbed area as above in July.

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Hazardous, Toxic, and Radioactive Waste (HTRW). In the summer of 2001, a Hazardous, Toxic, and Radioactive Waste (HTRW) Initial Assessment was completed for the purpose of identifying possible hazardous wastes and/or other environmental concerns within the Riverside Oxbow segment of the overall Clear Fork and West Fork study. Since the Riverside Oxbow study area was selected for more detailed study in November 2001, the study area has expanded in size to include the Gateway Park and Tandy Hills areas. Further HTRW Initial Assessments were completed for these new areas in February of 2002.

The HTRW Initial Assessment involved an environmental records search and a site visit. Environmental Data Resources (EDR), Inc. was procured to perform an environmental database search of all known sites of hazardous, toxic and radioactive waste concerns within a 1-mile radius of the study area. This search meets the requirements of ASTM E 1527-97, Standard Practice for Environmental Site Assessments. Three sites, within 200 feet of the proposed project lands, were identified as potentially hazardous. The locations listed are: TXI Operations at 3601 Lawnwood Avenue, H.J.G. Trucking at 701 Denair Street and Nationsrent at 1315 Riverside Drive. All three of these sites are in the commercial and light industrial area north of the oxbow. The report indicates that each of these sites has a Leaking Underground Storage Tank (LUST), which have impacted ground water. To date, none of the sites has received closure from TNRCC. However, all of the LUST sites are located outside of the boundary of the proposed project area and are not anticipated to adversely impact project lands in the future.

As a result of investigating the sites identified by the EDR search, further information was discovered regarding the TXI site. This site was the subject of controversy regarding hydrocarbon contamination in the soil during the installation of a north-south sewerage line sewerage line about three years ago. At that time, an investigation was conducted relative to the needs of the construction project and the project was completed. However, the site was not remediated and the hydrocarbons remain in the soil. The Fort Worth Environmental Department provided the study team with a map of the area identifying sites where soil samples were collected for analysis and the results of the analysis. There seems to be some conflicting information as to the extent of contamination. Preliminary indication is that project lands do not extend far enough north of the channel to intrude into this contamination. However, if the footprint of the project changes and subsequently incorporates some of this land, or if further delineation indicates that the existing contamination extends into potential project lands, the study team will work with the local sponsor and the city of Fort Worth to determine if additional investigation and possible remediation actions are warranted, or if the project should avoid the contaminated site.

The proposed project includes a wetlands area located within the sludge beds of an abandoned wastewater treatment plant. The city of Fort Worth has performed an investigation of the site in question and has provided a copy of the draft report to the study team. The report indicates the presence of several metals in the soils at levels exceeding TNRCC regulations for residential exposures. Fort Worth is currently performing a voluntary cleanup action of the site and is coordinating with TNRCC to achieve a clean closure; therefore the project will not be affected by the current conditions.

Hydraulics and Hydrology. As per regional floodplain management policy requirements, the CDC model was used as a basis for the baseline conditions modeling done for the Riverside Oxbow study area.

The baseline conditions model was further refined to incorporate recent modifications to the Fort Worth Floodway (from 4th Street to Riverside Drive), and modifications from Riverside Drive to Beach Street. The TRWD completed channel and bank excavation operations from the 4th Street Dam to Beach Street, including the construction of the 4th Street dam completed in November 1999. The dam is a roller-compacted concrete dam with a crest elevation 500.5 NGVD and a length of 284 feet. Work in this reach has resulted in an increase of conveyance for flood events within the Fort Worth Floodway. In addition, the TRWD recently constructed a low water dam below Beach Street. This dam is also a roller-compacted concrete dam with a crest elevation 494.5 NGVD and a length of 244 feet. This project was reviewed by USACE under the CDC program and determined to meet the applicable CDC hydrologic and hydraulic criteria.

The location of the project downstream of the Fort Worth Floodway and within the region covered by the ROD and CDC process results in a set of criteria that must be followed for any proposed project design that impacts lands within the floodplain. These criteria include: 1) no rise in the design flood water surface profile (SPF) is allowed (USACE); 2) no rise in the Base Flood Elevation (BFE) 100-year flood (Federal Emergency Management Agency); 3) condition outlined in the CDC process must be met; 4) Section 404 Record of Decision (ROD) that establishes hydrologic and hydraulic criteria for projects within the Trinity River floodplain in the Dallas-Fort Worth area, including no rise in water surface profile, no loss of valley storage, zero percent loss of valley storage in the 100-year event and no more than a maximum of five percent valley storage loss for the SPF event. The modified baseline conditions model was run to set existing conditions hydraulic values as a basis for evaluating changes to existing conditions values as the result of implementation of any proposed project design or restoration features. Applicable mitigation for water surface increases and valley storage loss may be necessary and will be incorporated in detailed project design.

A literature review was conducted by resource and hydrologic professionals to determine what the historic flow conditions would have been like on the West Fork and in the study area prior to implementation of any of the reservoirs or flood control projects upstream. Since construction of Lake Worth was completed by the city of Fort Worth in October of 1914, it was necessary to look for descriptions from the late 1800s to the early 1900s. Generally, narrative descriptions taken from old accounts by early settlers in the Fort Worth area or accounts by explorers traveling across the Cross Timbers and Prairies region of Texas indicate that the Trinity was a wide, shallow, slow moving stream under normal conditions, with depths averaging 2 to 5 feet. Indications are that the Trinity River had areas of dry channel bed along with deeper pools that served as refugia for recolonization of aquatic species only following extended periods of drought. As might be expected, the river was the main source of water for early settlers, with the area adjacent to the confluence of the West and Clear Forks being one of the early settlement sites.

FUTURE WITHOUT PROJECT CONDITIONS

The future without project conditions described in the following paragraphs are equivalent to a description of the "no action" alternative. In order to effectively evaluate changes to the environment of Riverside Oxbow study area if proposed ecosystem restoration measures are implemented, it is necessary to forecast likely future environmental conditions if they are not. Because the study area is located along a major river within a highly urbanized city, projection of any future environmental conditions needs to consider the upstream watershed along with the immediate study area.

Fort Worth, as part of the Dallas-Fort Worth Metroplex, is one of the fastest growing areas of Texas. It is anticipated that this population growth and development would continue. As a result, there would be additional construction and increased amounts of imperious surfaces such as roads, parking lots, and structures. These factors would add to the runoff within the Clear Fork and West Fork watershed and would increase the severity and/or frequency of flood within those neighborhoods currently affected by flooding problems, could add to the number of structures inundated, and would probably slightly raise the flood profile within the study area over time in the absence of any additional flood damage reduction activities.

It would be expected that water quality in the Clear Fork and West Fork watershed would degrade slightly to moderately in the future as Fort Worth and surrounding communities continue to develop. The construction of new residences and businesses would produce additional sediment load from runoff of construction sites. After completion, the increases in impervious surface area, traffic, lawn fertilizing and other human activities would have an adverse impact on the watershed. Degradation of the water quality would reduce the numbers of aquatic biota. The overall diversity of fishes and other aquatic species is already moderate; further loss of aquatic biota could therefore be significant.

Encroaching development and human activities would also be expected to negatively impact the watershed's existing vegetation, as well as that within the immediate study area. The forested riparian vegetation zone within much of the watershed is already either very narrow or non-existent and past trends indicate that this habitat type is being lost at a significant rate in the Upper Trinity River Basin. The number and size of the gaps in this riparian corridor would continue to increase and there would be fewer acres of forest in the future. The loss of habitat, particularly the bottomland hardwoods, would reduce the numbers of wildlife and bird species within the watershed. This is especially true for migratory songbirds, which are particularly susceptible to the loss of habitat along their migration routes.

RIVERSIDE OXBOW
FORT WORTH, TEXAS

CHAPTER 3
IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES

Regular study team meetings were held with the Tarrant Regional Water District, the USFWS, Streams and Valleys, Inc., the city of Fort Worth, GideonToal (under contract to the TRWD), USFWS, and a multidisciplinary water resources team from the U.S. Army Corps of Engineers, Fort Worth District to discuss and define problems and opportunities and to determine potential initiatives for flood damage reduction, ecosystem restoration, and recreation within the study area. Field surveys conducted to document the existing conditions of the natural resources within the study area were also utilized to identify specific resource needs and any constraints that might limit the implementation and future viability of potential ecosystem restoration measures. Comments and recommendations from the resource specialists were incorporated into a number of possible restoration measures appropriate to the habitat type, site location and existing conditions.

Flood Damage Reduction Problems and Opportunities. As noted in Chapter 2 under the Economic Analysis section, the Riverside Oxbow study area does not contain any damageable structures within the 100-year and SPF floodplains, therefore, the study team decided to limit any further investigation of flood damage reduction opportunities to those that might be incidental to …"environmental enhancement, water quality, recreation, and other allied purposes," as stated in the authorizing language for this study.

Ecosystem Restoration Problems and Opportunities. The Riverside Oxbow and surrounding area has experienced both direct and indirect environmental degradation as a result of the construction and implementation of Benbrook Lake, Eagle Mountain Lake, Lake Worth, the Fort Worth Floodway project, and subsequent flood control projects and development activities. According to the USFWS (1985), the indirect downstream effects of large flood control projects and reservoir construction on natural bottomland ecosystems are often more destructive, albeit not as immediate, as the direct impacts. Adverse impacts observed downstream include: 1) an unnatural bottomland hydroperiod causing major vegetational changes toward more xeric species as a result of the reduction in flooding; 2) the reduction of associated nutrient inputs to downstream bottomlands; 3) the loss of aquatic flora and fauna; 4) the loss of bank-stabilizing vegetation as a result of excessive bed and bank scour from irregular reservoir releases; 4) disruption of normal feeding and spawning cycles of fish which use floodplains; 5) elimination of high flows into bottomlands which prevents the input of bottomland nutrients into the aquatic system; and 6) potential negative effects to plant communities as a result of prolonged water releases during the growing season.

Within the state of Texas, it is estimated that more than 63 percent of the historical bottomland hardwoods and bottomland-forested wetlands have been lost due to reservoir construction and operation, agricultural conversion, timber production, channelization, and urban and industrial development (Texas Center for Policy Studies 1995). Numerous studies have documented the increasing scarcity of bottomland hardwood forests in Texas and the nation (Frayer et al. 1983; Fish and Wildlife Service 1985; Frye 1987). In fact, prior to European settlement Texas had approximately 16 million acres of bottomland hardwood riparian habitat. Today the state has less than 5.9 million acres.

It is well known that the floodplain bottomlands along rivers and streams in the Upper Trinity River Basin at one time made up the vast majority of the forested land cover in the region. Trend analyses indicate that there has been a significant loss of forested lands and a marked corresponding increase in the acres of managed grasslands in the Upper Trinity River Basin. These analyses, included in the Final Programmatic Environmental Impact Statement for the Upper Trinity River Basin, dated June 2000, indicate between 1984 and 1995, there has been an approximate 14.4 percent loss of forested land cover. Also indicated was a corresponding 13.6 percent increase in managed grasslands in the Upper Trinity River Basin, which encompasses the Riverside Oxbow study area.

The impoundment and operation of Benbrook Lake on the Clear Fork, Eagle Mountain Lake and Lake Worth on the West Fork have not only destroyed bottomland hardwoods and their associated wetlands, but have also caused the loss and degradation of the tall grass prairies which historically made up the major component of the landscapes in this region of Texas (Fort Worth Prairie component of the Grand Prairie within the Cross Timbers and Prairies ecoregion). In presettlement times, woodlands were only found as narrow ribbons of bottomland stands along the major watercourses, as scattered mottes in the prairie grasslands or associated with draws and drainages of upland mesas and buttes. The vast majority of these grasslands have been altered by grazing, agricultural development and urban development activities and no longer support the habitat quality and diversity of the original prairie associations. Prior to settlement, there were 12 million acres of prairie in Texas extending from San Antonio to the Oklahoma border. According to the Texas Environmental Almanac (1995), today, less than 1-percent of these prairie lands remain.

Aquatic resources within the study area include the West Fork of the Trinity River and small ephemeral wetlands and ponds. All of these bodies of water have been modified and encroached upon by urbanization, flood control projects and agriculture activities. Specific impacts of these types of activities on the aquatic fauna and flora in the study area include: 1) a reduction in the benthos production as a result of less food and habitat in and along the river; 2) reduction of cover, spawning and nursery habitat for fish; 3) disruption of fish territory and migration patterns; 4) reduction in plankton production; and 5) a redistribution and reduction of organic matter.

The operation of the reservoirs has also had an adverse impact on water quality. The reduction in downstream flooding has increased the amount of land available for agricultural production and urban development. In addition to the clearing of bottomland and floodplain forests for agricultural land and urban development, activities such as plowing, clearing, grading and/or grazing disturb the soil, thereby affecting the survival of

invertebrates. These activities have also cause erosion problems and increased the rates of sedimentation. In turn, the quality of the water is adversely impacted by these and various other upland activities, including fertilizer, pesticide and herbicide applications on agricultural fields and lawns, waste water treatment processing and point- and non-point source pollution from local runoff. At the outset of this study, the Tarrant Regional Water District, as the local sponsor for this study and a major water supply entity in the region, expressed interest in improving and protecting water quality within the study area.

The modifications of the natural habitat of the floodplains of the Upper Trinity River and major tributaries, as described above, have subsequently impacted the aquatic and terrestrial wildlife species utilizing the ecosystem. By itself, any of these impacts would cause some degree of degradation to the aquatic and bottomland hardwood habitat downstream; when combined, the significance of the degradation to the quantity and quality of the downstream habitat becomes increasingly significant. According to the Texas Environmental Almanac (1995), the overwhelming loss of and threats to wildlife, plants and natural communities are a direct result of habitat alteration and destruction. The study team recognized the loss and alteration of habitat quality and quantity as a major concern within the study area.

Based upon on-site investigations conducted during feasibility level studies on the Riverside Oxbow area, the following problems were observed that limit environmental quality of the area. The channelized segment of the currently carries all flows associated with the West Fork. Flows only occur in the oxbow from localized runoffs. Occasional backwater from the West Fork inundates the segment extending upstream to Beach Street but, even then, an 84-inch diameter wastewater pipeline that crosses the oxbow at the downstream confluence with the West Fork inhibits fisheries use of the oxbow channel. The Beach Street crossing of the oxbow also blocks backwater movement and limits use of the oxbow for spawning, rearing and general sanctuary for fish that need to escape the high velocities that occur in the main channel during prolonged flood events and operational releases.

The construction techniques used at the Beach Street crossing limits the ability of non-avian wildlife to utilize the riparian corridor. Reconfiguration of this crossing could effectively fully reconnect the 1.2 mile riparian segment along the oxbow channel between Riverside Drive and Beach Street with the West Fork riparian corridor which extends downstream continuously without similar obstructions all the way to the existing Dallas Floodway, a distance of approximately 41.4 river miles.

During the approximately 30-year period since the oxbow was effectively separated from the modified West Fork channel and from the beneficial effects of the river flowing through the channel, several changes have occurred. Sloughing of the bank and sedimentation from other sources has caused a narrowing of the channel to approximately 30 to 40 feet in width. The natural West Fork channel width downstream of this area is currently in excess of 120 feet. Thick growths of vines and invader trees and shrubs have developed on the first bench of the old channel, limiting habitat quality for terrestrial and aquatic habitats. The invading vegetation has further trapped silt and debris from the flood events resulting in a raised stream bottom. Currently, the Riverside oxbow segment of the West Fork channel is a series of small isolated pools during most of the year.

Because the soils adjacent to the old river channel no longer have a continual source of flowing water to keep them moist, many of the native trees located along the channel have experienced stress, which has inhibited their growth. Some have even died, only to be replaced by non-native invaders that have low value to wildlife. These invaders species include escaped ornamental plants, such as nandina and honeysuckle, and even worse, Chinaberry and naturalized privets of the Ligustrum genus. The Nature Conservancy has identified Ligustrum as a serious invader in this and other natural areas of the Southeast. According to information retrieved from the Nature Conservancy, Internet web site, http://tncweeds.ucdavis.edu/worst/ligustr.html map on August 29, 2002, "*Its (non-native privet) fruit are not particularly good forage, but since large numbers of fruit are produced hungry birds end up eating some of it (especially since the privet probably displaced a native species that would have fed the birds). In this way, privet spreads–rapidly! Every privet plant in the wild is depleting the resources for native wildlife.*"

Within the riparian corridor, including the riparian stringers located south of IH-30, non-native invaders quickly occupy temporary openings on the forest floor caused by natural processes such as death (due to disease or old age), lightning strikes and wind throw. Similar invasion has been observed at sites where erosion caused by man's activities has impacted the native vegetation. Native shrubs, which used to support wildlife, have slowly been replaced through this invasion. Hard mast producers, such as pecans and oaks, are also slowly being replaced in this same manner, usually by Chinaberry trees.

Several small areas of another invader, the Tree-of-heaven, which is native to China, have been noted in an area upstream of the study area. Once established trees like the privet, Chinaberry and the Tree-of-heaven are very hardy, can thrive in a wide variety of soil and climate conditions, have tremendous reproductive capability and, essentially, will out-compete other native vegetation along the riparian corridor. Left in an unmanaged situation, these non-native invaders could ultimately become so widespread along the riparian areas that restoration potential would become severely limited. Active management on a large scale that includes nearby sources of re-infestation would increase the chances for restoration of native shrub and midstory layer plants within the area.

Within portions of the study area outside of the oxbow channel and the immediate riparian corridor, other man-induced changes have occurred that collectively have reduced the environmental quality of the area. The previously mentioned alteration of hydroperiod brought about by the construction of upstream reservoirs, for both flood control and water supply, coupled with the effects of channelized upstream reaches of the West Fork and Clear Fork, have resulted in loss of small emergent wetlands along the floodplain. Overbank flows within the area, formerly eroded narrow, linear cuts in the floodplain that developed into wetlands. With control of the flooding this does not occur as it once did and, as is part of the natural process of trapping nutrients and sediments, many of the older wetlands have slowly converted back to grasslands and shrublands. The existing cutoff of the old Sycamore Creek, which was created when the modified channel was constructed and the creek was cutoff from flows between the modified channel and the oxbow, is already showing signs of filling and bank sloughing. Only a small portion of the cutoff reach of Sycamore Creek currently contains water for a sufficiently long period each year to retain wetland features.

Within the natural floodplain of the West Fork adjacent to the oxbow and to the natural channel downstream, gravel and topsoil excavations and fills have disturbed and reduced the overall quality of the riparian resources. Land uses currently result in the manicuring of grasslands up to the very edge of the existing resource areas of significance, primarily the wooded areas, and the developed wet areas associated with the excavations.

Habitat evaluations conducted during the course of the feasibility strongly reflected the result of the forces of many past actions and continuing operational measures on the environment within the Riverside Oxbow study area. Wetland and grassland values were found to be unusually low for the Upper Trinity Basin. Forested areas were also low compared to other sites located in other areas of the Upper Trinity Basin.

Recreation Problems and Opportunities. TRWD, their contractor, GideonToal, and Streams and Valleys, Inc. conducted several public meetings in the summer of 2000 to solicit input from local neighborhoods and citizens about their interests and concerns for the Clear Fork and West Fork and tributaries throughout Fort Worth. The meetings were well attended by citizens and special interest groups who use the existing Trinity trails or the river for recreation activities and/or who are interested and concerned for the natural resources within the floodplain. Based on these meetings, an area of concern identified was the lack of continuity and access to trails along the Trinity River and the need for additional water- and land-based recreation experiences along and within the river to accommodate a wide variety of public interests, including hiking, biking, bird watching, canoeing, kayaking, fishing, horseback riding, etc.

RIVERSIDE OXBOW
FORT WORTH, TEXAS

CHAPTER 4
PLAN FORMULATION

According to U.S. Army Corps of Engineers' Policy and Planning Guidance for Conducting Civil Works Planning Studies (ER 1105-2-100), ecosystem restoration projects should be formulated in a systems context to improve the potential for long-term survival of aquatic, wetland, and terrestrial complexes as self-regulating, functioning systems. This chapter details the steps that were taken to formulate a plan that meets the guidance, considers the constraints, and best meets or exceeds the Riverside Oxbow study planning objectives as set forth below. Alternative measures were identified and the beneficial and adverse contributions of each alternative measure were then evaluated against existing and future without project conditions. Finally, the remaining alternative measures were compared against each other using cost effectiveness and incremental analyses.

OBJECTIVES

Based on the existing conditions investigations, the local, regional, state, and national problems identified and with input from resource agencies, the general public, the local sponsor, and study team members, the following planning objectives were developed for the Riverside Oxbow study area. These objectives include:

- Improve the quality and increase the quantity of the riparian and bottomland hardwood habitat for the benefit of multiple species of birds and wildlife;
- Improve the quality and increase the quantity of the emergent wetland habitat to restore nesting, brood rearing, and wintering habitat for multiple species birds and wildlife;
- Reestablish a contiguous riparian corridor to allow unobstructed migration of avian and wildlife species;
- Restore a more natural hydrologic regime;
- Restore and improve aquatic habitat for fish and other aquatic organisms;
- Improve and restore habitat for migrant neotropical birds and waterfowl, as well as residential wildlife species;
- Reduce the fragmented nature of the bottomland hardwood habitat;
- Provide a sustainable level of food, nesting, and cover for all wildlife communities;
- Protect and buffer the riparian habitat from adjacent land uses and encroaching development activities;
- Restore the stability, function, and dynamic processes of the floodplain to a more natural, less degraded condition;

- Protect and increase habitat diversity and the interspersion of habitat types, including the remnant prairie habitat and associated drainages of Tandy Hills;
- Improve the water quality in conjunction with other ecosystem restoration activities; and,
- Improve the aesthetics, as well as the recreational and educational opportunities that are compatible with ecosystem restoration activities for a wide variety of interests.

CONSTRAINTS

The study team identified several constraints within the study area that had significant impacts on the types, methods, and/or scales of restoration activities that could be implemented. These constraints included:

- CDC and ROD hydrologic and hydraulic criteria apply – no increase in 100-year and SPF water surface elevations and no loss of valley storage for the 100-year flood discharges and no more than 5 percent loss for the SPF discharge;
- The location of Interstate Highway 30, which bisects a portion of the study area;
- The location of commercial businesses in the real estate tracts north of the oxbow;
- The location of residential homes in the real estate tracts in and adjacent to the Tandy area;
- The city of Fort Worth's Recreation Master Plan for the existing and potential future lands within and adjacent to Gateway Park;
- Avoid and/or minimize adverse impacts to identified archeological or buried cultural resources;
- Avoid and/or minimize clean up of any identified hazardous or contaminated sites;
- Minimize required operation and maintenance efforts and expenses;
- Prior commitments and agreements between the local sponsor and adjacent landowners within the study area;
- Previous Section 404 permitted activities and associated hydraulic and hydrologic mitigation requirements in and/or adjacent to the study area;
- Recommended plan must be supported by the local sponsor in order to facilitate implementation.

ECOSYSTEM RESTORATION MEASURES AND ALTERNATIVES

Measures are features or activities that can be implemented at specific sites to address one or more of the planning objectives. As the next step in the plan formulation process, the study team identified a variety of restoration measures and/or scales of measures for each zone in the study area. Since bottomland hardwoods, wetlands, grasslands, and aquatic habitats are identified as prevalent floodplain habitat types in the Prairies and Cross Timbers ecoregion, which encompasses the study area, the identification of restoration measures for each of these systems is discussed in the following paragraphs.

Any restoration activity requires some form of real estate interest. For the purposes of this feasibility study, fee title acquisition was determined to be the appropriate real property interest. As such, fee title costs are included in the plan formulation process for evaluating and comparing restoration measures by combining the annualized costs of real estate into the annualized costs for each of the restoration measures for each zone on a per acre basis. The only exception to this is in the Tandy zone where the study team looked at several different scales of land acquisition, each having unique restoration opportunities.

The restoration measures discussed below have been numbered in order to help identify those measures in further discussions and reference tables..

BOTTOMLAND HARDWOODS. Several of the planning objectives established for this study rely upon reforestation of bottomland hardwoods or habitat improvements to existing bottomland hardwood tracts as restoration methods. For the purposes of this study, reforestation measures are those activities that would be implemented to convert existing non-wooded habitat types to bottomland forest stands, while habitat improvement measures are those activities undertaken within existing bottomland hardwood stands to improve the quality of the habitat.

Reforestation of Bottomland Hardwoods – Coverage Density (Measure 1A). While reforestation of the entire floodplain would help meet several of the planning objectives, reforestation in the study area would also affect hydraulic efficiency and could potentially impact the 100-year and SPF water surface elevations and valley storage criteria established by the CDC program. In order to quantify these impacts and optimize the extent of reforestation that could be undertaken in the area, hydraulic models were developed to evaluate the potential impacts that different levels of reforestation would have on water surface profiles. The levels of reforestation were based on - 10, 25, 50, and 100 percent tree cover densities. Each hydraulic model developed for the increasing levels of reforestation produced increased water surface elevations, as compared to the West Fork baseline conditions. The increases were caused by the additional roughness in the floodplain due to the increase in tree coverage. Once the increases in water surface elevation were established, the level of hydraulic mitigation required to offset any rise in water surface elevations was developed (models included the most efficient method of hydraulic mitigation, which is to remove, or excavate, material along the banks of the river channel.)

Table 4
Summary of Tree Coverage Densities to Water Surface Elevations and Potential Hydraulic Mitigation Requirements

Tree Coverage Densities	Range of 100-year Flood Water Surface Elevation Increases	Required Hydraulic Mitigation (Cubic Yards of Excavation)
10 percent	0.2 – 0.3 feet	100,000 cy
25 percent	0.4 – 0.5 feet	350,000 cy
50 percent	0.6 – 0.7 feet	580,000 cy
100 percent	0.8 – 1.2 feet	730,000 cy

While the table seems to indicate that any of the alternative tree cover densities would be viable, excavation in excess of 100,000 cubic yards (cy) requires excessive widening of the existing modified channel, or would require channel modifications downstream of the confluence of the oxbow with the West Fork. Neither option is viable. Removing existing riparian vegetation to mitigate for adverse hydraulic impacts of adding new vegetation would be counterproductive. Any excavation beyond 100,000 cy would necessitate the relocation of an 84-inch sewerage line, which would significantly increase project costs. Further, since the river channel in this area has not been modified and is in its natural alignment and condition, environmental mitigation would be required for any adverse impacts to the channel. U.S. Army Corps of Engineers policy and guidance (ER 1105-2-100) does not allow for ecosystem restoration requiring fish and wildlife mitigation. Therefore, reforestation of bottomland hardwoods is constrained by required hydraulic mitigation to the 10 percent level.

Reforestation of Bottomland Hardwoods – Corridor Width (Measure 1B). Another reforestation parameter considered is corridor width. One of the project objectives is to establish or maintain some minimum width of continuous riparian corridor throughout the project area. A literature review conducted by resource professionals to determine the optimal width of the riparian corridor for the study area, indicate that a riparian zone of less than 50 meters (approximately 165 feet) does not provide suitable habitat for many of the neotropical migrants. Riparian zones of 100 to 150 meters (approximately 330 to 495 feet, respectively) are sufficient to maintain functional assemblages of the six most common species of breeding neotropical migratory birds. A riparian corridor of 100 to 150 meters will provide sufficient breeding habitat for area-sensitive forest birds and have more abundant populations of neotropical migrants than riparian areas of less width, which are inhabited mainly by resident or short-distance migrants.And, finally, riparian zone of at least 500 meters (approximately 1650 feet) is necessary to maintain the complete avian community. Using this information, resource specialists determined that the riparian corridor needed to be at least 100 meters wide, and preferably 500 meters wide, to significantly improve habitat benefits for multiple avian and wildlife species.

A real estate evaluation for these two reforestation measures determined that the 100-meter wide corridor would not require relocation of any of the commercial businesses located west and north of the oxbow channel, while implementation of a 500-meter wide corridor would require the acquisition and relocation of a number of businesses. This would substantially increase the real estate costs of the proposed project. In addition, implementation of a 500-meter wide riparian corridor would require planting approximately 200 acres of additional trees in the study area, which is well above the 10 percent limit established for reforestation efforts in the study area. The number of acres requiring reforestation for a 100-meter riparian corridor would be approximately 20 acres, well within the 10 percent limit. Therefore, the goal of restoration efforts for the riparian corridor in the study area was established as a riparian zone of at least 100 meters wide, where possible.

Reforestation of Bottomland Hardwoods – Planting Densities and Materials (Measure 1C). The density of plantings, the type of the plant material, and the size of the

planting stock for the trees and shrubs would have an impact on the level of restoration, especially in the short term. The size of the plants can range from seeds and acorns to seedlings to containerized stock. Evaluation of different scales of planting densities, types of plant materials, and size of plant stocks is based on recommendations from resource specialists. These scales were then included in cost effectiveness and incremental analyses to determine which reforestation scale would provide the most habitat gains for the cost of implementation. The following reforestation scales were evaluated:

- No action (R0)
- 60 one-inch caliper containerized trees, 30 one-gallon containerized shrubs, and 100 seedlings per acre (R1)
- 40 one-inch caliper containerized trees, 20 one-gallon containerized shrubs, and 150 seedlings per acre (R2)
- 20 one-inch caliper containerized trees, 10 one-gallon containerized shrubs, and 200 seedlings per acre (R3)
- 300 bare root tree seedlings and 150 bare root shrub seedlings per acre (R4)

A variety of combination plans were ultimately evaluated using these variations on reforestation density/material parameters. Results are included in a subsequent section of this chapter.

Improvement of Existing Bottomland Hardwood Habitat (Measure 2). There are currently approximately 300 acres of bottomland hardwood habitat in the study area. USFWS and Corps biologists conducted Habitat Evaluation Procedure (HEP) on sample plots using habitat suitability models for specific species that represent the guilds for each vegetation type, including riparian hardwoods. The field data were used to identify the limiting factors and to compute a numeric value for the existing habitat quality. Primary limiting factors for the riparian or bottomland hardwoods are lack of hard mast, lack of soft mast (fruits), proliferation of non-native species in the understory layers, dense thickets that preclude bird of prey movement and prohibit regeneration of climax vegetation, and lack of cavities in hardwood trees.

Habitat improvement measures identified include planting of hard- and soft-mast producing trees and shrubs, placing of nesting boxes for wood ducks and other bird species, and application of forest management techniques such as selective thinning to remove non-natives and understory vegetation. The following range of habitat improvement scales was evaluated:

- No action (H0)
- 10 one-inch caliper containerized trees, 7 one-gallon containerized shrubs and forest management techniques (thinning, nesting boxes, etc.) per acre (H1)
- 5 one-inch caliper containerized trees, 5 one-gallon containerized shrubs and forest management techniques (thinning, nesting boxes, etc.) per acre (H2)
- 2 one-inch caliper containerized trees, 2 one-gallon containerized shrubs and forest management techniques (thinning, nesting boxes, etc.) per acre (H3)

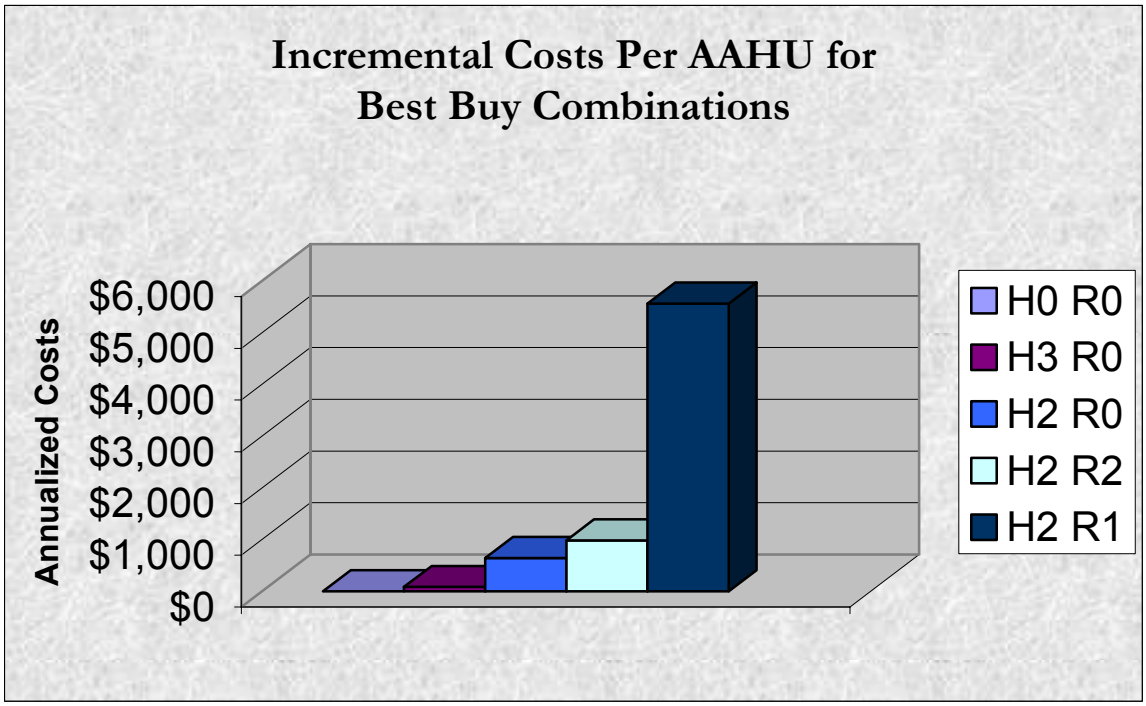
Reforestation/Habitat Improvement "Best Buy" Combinations. Comparative analysis techniques (Robinson et al. 1990) were used to determine the most cost effective combinations of scales for reforestation and habitat improvement. For each of the measures and scales identified above, a "no action" measure was developed. Annualized habitat unit gains for each measure/scale and the no action counterparts were computed over the 50-year life of the project. Annualized costs, including operations and maintenance costs, were computed for each of the measures and their "no action" counterparts. These data were then input into IWR-Plan: Decision Support Software, Version 3.3 to determine cost effectiveness and incremental cost analyses. Results of the analysis identifying the best buy combinations and associated incremental costs are shown in Table 5.

Table 5
Incremental Cost of Best Buy Combinations for Reforestation and Habitat Improvement Scales

Scale	AAHUs	Incremental AAHUs	Annualized Costs	Incremental Annualized Costs	Average Cost Per AAHU	Incremental Cost Per Output
H0 R0	43.25	43.25	$0	$0	$0.00	$0
H3 R0	108.99	65.74	$5,563	$5,563	$51.04	$84.62
H2 R0	122.83	13.84	$14,463	$8,900	$117.75	$643.06
H2 R2	166.93	44.1	$57,772	$43,309	$346.09	$982.06
H2 R1	168.33	1.40	$65,555	$7,783	$389.44	$5,559.29

Figure 6 depicts the AAHUs and annualized costs for all the best buy combinations for reforestation and habitat improvement scales. Based on this analysis, the study team determined that the best buy combination H2 R2 is the combination of choice. Therefore, all further discussion or evaluation of reforestation and bottomland hardwood habitat improvement measures in this study are based on this optimized combination. The reforestation measure includes 40 one-inch caliper containerized trees, 20 one-gallon containerized shrubs, and 150 seedlings per acre. The bottomland hardwood habitat improvement measure includes 5 one-inch caliper containerized trees, 5 one-gallon containerized shrubs and forest management techniques (selective thinning, nesting boxes, etc.) per acre.

Figure 6
Best Buy Combinations for Reforestation and Habitat Improvement Scales



WETLANDS. Several of the planning objectives identify restoration of wetland habitat as a key component. As with the bottomland hardwoods, opportunities to improve wetland habitat across the study area are found both through creation of new wetland complexes and improvement to existing wetlands. Both strategies are discussed below.

Creation of Wetlands – Size (Measure 3A). One of the measures considered to improve the quality and increase the quantity of wetlands in the study area includes the creation of new wetland complexes. In identifying potential locations for the construction of new wetland complexes, the study team identified sites that had the greatest potential to mimic the functional value and dynamic processes of wetland habitat that would have existed within the Trinity River's floodplain under historic conditions. Two sites were determined to be suitable for development of new wetland complexes. The first site is an old remnant scar of Sycamore Creek in the Oxbow Center zone. This remnant defines the original channel of Sycamore Creek near its confluence with the natural channel of the West Fork prior to the construction of the modified channel between Riverside Drive and the confluence of the oxbow and the West Fork downstream of Beach Street. Currently there are several scattered large pecan trees along this old river meander. In evaluating the

development of a wetland complex in this area, the study team looked at three different sizes for the complex – 5.1 acres, 12.3 acres, and 17.8 acres, respectively, utilizing to a varying degree the topography of the old remnant meander.

Both the 5.1-acre and 12.3-acre wetland complexes could be constructed within the remnant scar where the topography is lower than the surround lands, thereby minimizing the quantity of excavation needed and limiting construction costs. Proportionally, the 17.8-acre complex would require increased amounts of excavation for its size. According to resource specialists, the relatively small size of the 5.1-acre wetland complex would not allow for a wide variation in water depths which would in turn limit the vegetation types (emergent, submerged, floating, etc.) and subsequently the variety and quantity of waterfowl and shore birds it would support. It was determined that each of the two larger complexes evaluated could be constructed with a deeper water pond and several smaller shallower water cells. The deeper pond would serve as holding tank for water that could then be disbursed to shallower cells, as needed. The shallower cells would be constructed with maximum water depth of less than 3 feet, which would allow the development of emergent wetland vegetation that is utilized by a wide variety of aquatic and wildlife and bird species as sources for food, cover, and reproduction. The deeper water pond, with a maximum depth of 6 to 8 feet, would provide open water habitat needed by certain species of waterfowl and serve as a refuge site for aquatic organisms and a holding tank to supply water to the shallow cells during extended periods of drought. All these factors would increase the value of the wetland complex for a wide variety of waterfowl and shore birds. All three sizes were carried forward for further evaluation.

The second site identified for creation of a wetland complex is in the old wastewater treatment drying beds located in Gateway East. As with the remnant scar of Sycamore Creek, the use of the drying beds to construct a wetland complex would minimize the amount of excavation needed and, therefore, the costs of implementation. Again, the study team evaluated 3 different sizes of wetland complexes for this site – 15.0 acres, 26.8 acres, and 35.0 acres, respectively, mostly utilizing the topography of the existing drying beds. Both the 15-acre and 26.8-acre complexes could be constructed generally within the confines of the drying bed boundaries, although the 26.8-acre wetland would also utilize a low-lying area north of the uppermost bed. Creation of the 35-acre wetland complex was quickly dropped from consideration in the formulation process for this site when it became apparent that construction of a complex this size would not only incur proportionally greater costs for excavation, but would also cause adverse impacts to some existing bottomland hardwood tracts. A wetland complex of either the 15.0-acre or 26.8-acre size would maximize the use of the topography within the existing drying beds. Both the 15.0 and 26.8-acre wetland sizes were carried forward for further evaluations.

Creation of Wetlands – Water Control and Plantings (Measure 3B). Construction of any of the different sizes of wetland complexes discussed above could include the planting of native wetland vegetation and the addition of water control structures. The planting of wetland vegetation would help to eliminate the prolific growth of weedy species that are often the first plant species to colonize an area following a period of disturbance, such as the construction activities associated with creation of a wetland complex. In addition, adding endemic wetland plant material provides seed sources and

propagules for continued growth and expansion of this quality wetland vegetation as the wetland complex matures.

The addition of water control structures would allow manipulation of water levels and retention time to promote the growth of quality wetland vegetation. One unique feature in the Gateway East zone is a u-shaped wetland located north of the drying beds. This wetland, which is located adjacent to some better quality woodlands, is an old naturally occurring oxbow remnant that receives water from the West Fork of the Trinity River during periods of high flows. Currently, the oxbow contains water only during the wet season. The location of debris and the flow patterns through soft-stemmed vegetation following a significant rain event indicate that water enters the oxbow through a small channel from the riverbank under an existing concrete sidewalk. Analysis of the topography of the Gateway East zone indicates that the flow of water from the created wetlands in the old drying beds could be drained north toward the u-shaped wetlands with the addition of a water control structure. The addition of this water control structure would improve the hydrologic regime of the u-shaped wetland by providing a reliable water source. Since fish and amphibians are known to utilize the oxbow wetland, this would not only improve the quality of wetland habitat, but also improve the quality of aquatic habitat. The addition of a water control structure to connect the u-shaped wetlands to the created wetland complex in the Gateway East zone was incorporated as a component of the created wetland plans for analysis.

Creation of Wetlands – Water Source (Measure 3C). Most of the existing wetlands and ponds in the Riverside Oxbow study area are very ephemeral in nature. Many dry up completely in the long, dry Texas summers. Even the largest of them have been so reduced in size following periods of sustained drought that they no longer provide wetland habitat. The primary reason for this is the implementation of reservoirs and flood control projects upstream of the project area that control flooding to such an extent that out of bank flooding is relatively infrequent. One of the measures identified for improving the quality of wetland habitat in the study area is to provide a reliable water source by pumping water out of the river channel as necessary. There are two methods of doing this. One option would be to use portable pumps and pipes. A second option would be the construction of permanent pump stations with pumping equipment specifically design for the individual wetland complex. According to the resource specialists, the habitat benefits of water pumping would be slightly greater for a permanent pumping station since these stations would be built into the ground which would minimize potential adverse noise impacts, trash and debris collection problems, and potential safety concerns that would be expected with mobile pumps and flexible hose or pipes lying on the ground. However, the primary difference between these two options is in their life-cycle costs. When annualized costs were computed, the permanent pump is slightly less costly over the 50-year life of the project than the temporary pump option. Table 6 presents the results of the analysis of the annualized costs associated with the two alternative water source options including operation and maintenance costs. Based on the results of the analysis, permanent water source stations were determined to be the most cost effective water source option. All further discussion or analysis of water supply as a wetland restoration measure and/or scale in this report assumes the construction of a permanent water supply station.

Table 6
Annualized Cost Analysis for Alternative Water Sources for Created and Improved Wetlands

INVESTMENT COST	PERMANENT PUMP	TEMPORARY PUMP
First Cost	$58,449	$19,361
Annual Interest Rate (decimal)	0.6125	0.6125
Project Life (years)	50	50
Construction Period (months)	12	12
Interest During Construction	$1,922	$637
Investment Cost	$60,371	$19,998
AVERAGE ANNUAL CHARGES		
Interest	$3,698	$1,225
Amortization	$199	$66
Operations and Maintenance	$500	$2,000
Replacements	$0	$1,162
TOTAL ANNUAL CHARGES	**$4,397**	**$4,453**

The scales for the restoration of created wetland complexes in Oxbow Center and Gateway Beach are detailed below.

Oxbow Center:

- No action (A0)
- Create a 5.1 acre wetland (A1)
- Create a 12.3 acre wetland (A2)
- Create a 17.8 acre wetland (A3)
- Create a 5.1 acre wetland plus water control and plantings (A4)
- Create a 12.3 acre wetland plus water control and plantings (A5)
- Create a 17.8 acre wetland plus water control and plantings (A6)
- Create a 5.1 acre wetland plus water control, plantings, and water source (A7)
- Create a 12.3 acre wetland plus water control, plantings, and water source (A8)
- Create a 17.8 acre wetland plus water control, plantings, and water source (A9)

Gateway Beach:

- No action (A0)
- Create a 15 acre wetland (A1)
- Create a 26.8 acre wetland (A2)
- Create a 15 acre wetland plus water control and plantings (A4)
- Create a 26.8 acre wetland plus water control and plantings (A5)
- Create a 15 acre wetland plus water control, plantings, and water source (A7)
- Create a 26.8 acre wetland plus water control, plantings, and water source (A8)

Because the size of the wetland complexes would impact the number of acres available for other potential restoration within the Oxbow Center and Gateway Beach zones, interim analyses were conducted to determine the most cost effective wetland restoration measures for both sites. For each of the measures and scales identified above, a "no action" measure was developed. Next annualized habitat unit gains for each measure/scale and the no action counterparts were computed over the life of the project, including operations and maintenance costs. This data was then input into the IWR-Plan comparative analysis model. Tables 7 displays the average annual habitat units and annualized costs for each of the wetland complex measures input into the analyses in Oxbow Center and Gateway East, respectively, and the incremental costs per output for the "best buy" combination of measures or scales.

Table 7
Incremental Cost of Best Buy Combinations for Created Wetland Complexes

	Oxbow Center			Gateway East		
Measure or Scale	**AAHUs Gained**	**Annualized Costs**	**Average Annual Cost/HU**	**AAHUs Gained**	**Annualized Costs**	**Average Annual Cost/HU**
Small wetland (A1)	1.54	$5,850	$3799	4.51	$22,445	$4977
Medium wetland (A4)	3.70	$12,696	$3431	8.07	$39,422	$4885
Large wetland (A7)	5.36	$23,617	$4406	10.53	$57,803	$5489
Small wetland + plantings & water control (A2)	2.87	$8,821	$3073	8.44	$27,876	$3302
Medium wetland + plantings & water control (A5)	7.66	$16,857	$2201	16.70	$45,350	$2715
Large wetland + plantings & water control (A8)	11.09	$29,418	$2653	21.63	$64,677	$2990
Small wetland, plantings, water control + water supply (A3)	3.45	$13,015	$3772	10.15	$29,721	$2928
Medium wetland, plantings, water control + water supply (A6)*	10.94	$21,115	$1930	23.84	$47,272	$1983
Large wetland, plantings, water control + water supply (A9)*	15.84	$33,676	$2126	31.14	$66,523	$2136

* Best Buy combinations

Based on the cost effectiveness and incremental analyses of wetland measures and scales, the study team determined that, for both sites, combination A6, or the medium-sized wetland

with plantings, water control, and water supply was the combination of choice. Specifically, the optimized wetland complex in Oxbow Center would be 12.3 acres in size and the wetland complex in Gateway Beach would be 26.8 acres in size. Both complexes would include a water control structure(s), wetland plantings, and a permanent water supply to be used as necessary to protect the functional integrity of the wetlands during extended periods of drought.

Improvement of Existing Wetland Habitat. Remnant wetlands are currently found in several locations throughout the study area. These wetland complexes are highly impacted and significant potential exists to improve the habitat they provide using a variety of strategies discussed below.

Improvement of Existing Wetland Habitat – Recontouring (Measure 4A). The modification of two ponds in the Gateway Beach zone would improve the quality of wetland habitat in the study area. Recontouring the edges of these water bodies to establish more shallow slopes and terraces would expand the acreage of wetland vegetation.

Improvement of Existing Wetland Habitat – Recontouring of Wetlands Plus Water Control and Plantings (Measure 4B). The addition of a water control structure between the two ponds in the Gateway Beach zone would allow manipulation of water levels to maximize wetland vegetation growth and hydraulically connect the two cells. Planting quality wetland vegetation in the shallow zones and modification of the forested vegetation surrounding the wetlands to remove some non-native species, plant some hard- and soft-mast producers, and thin the understory to more natural conditions would help to restore food, cover, and reproductive habitat for multiple species of wildlife and birds.

Improvement of Existing Wetland Habitat – Recontouring of Wetlands With Water Control and Plantings Plus Water Supply (Measure 4C). Just as improvements to created wetland complexes were evaluated for the addition of water supply so was this component evaluated for the existing ponds in the Gateway Beach zone. Under typical conditions in the midst of the long, hot, dry summers in Texas, the smaller of these two ponds is often dry and the larger one is greatly reduced in size. These wetlands are not able to support as great a population of aquatic, wildlife, and bird species as during the typical winter months when rainfall and thus water supply is more plentiful. Based on the cost analysis outlined in Table 5, the permanent water pump station was the water supply measure included in further analysis.

Improvement of Existing Wetland Habitat – Recontouring of Wetlands With Water Control, Plantings, and Water Supply Plus Removal of Old Gateway Park Road (Measure 4D). The location of the park entrance road off Beach Street serves as a barrier to a natural hydraulic connection between the wetlands in the zone and the oxbow to the south. Personnel from the Fort Worth Parks and Community Services Department stated that there are future plans to move the entrance road to Gateway Park. When this is completed a portion of the old park entrance road would become obsolete. One of the measures identified by the study team to improve the quality of the wetland habitat in the Gateway Beach zone would be to remove this road bed once the new entrance to Gateway

Park is constructed and restore the hydraulic connection between the wetlands in the zone and the oxbow.

Improvement of Existing Wetland Habitat – Adding a Water Control, Structure (Measure 4E). During existing conditions surveys, resource specialists identified one location where the addition of a water control structure would improve the quality of existing wetland habitat. This site is the pond located north of the oxbow east of Beach Street in the Oxbow North zone.

The placement of a water control structure with a spillway in the large pond located west of Beach Street and north of the oxbow would allow for water levels to be manipulated maximizing the growth of wetland vegetation. Besides restoring wetland benefits to the area, this pond also provides water quality benefits to the oxbow by capturing much of the local runoff from residential neighborhoods north of the oxbow that runs along the west side of Beach Street.

Analyses of the Gateway Beach wetland habitat improvements measures outlined above were included in the overall analyses for the study area, as was analysis of adding a water control structure to the North Pond in Oxbow North.

GRASSLANDS. In reviewing the vegetational history of the study area to identify restoration opportunities, resource specialists discovered that grasslands and grasslands with tree mottes made up a large portion of the floodplains. Not only would the addition of a grassland component mimic historical conditions, but it would also provide multiple habitat benefits and help to provide a sustainable source of food, nesting, and cover for multiple avian and wildlife species, both migrants and residential.

Grasslands – Buffer Strip along Riparian Corridor (Measure 5). During the literature review conducted by resource specialists several references included discussion of the benefits of grassland buffer strips either in conjunction with a wooded riparian component or as a stand-alone restoration measure, where applicable. A California study conducted by graduate students, Marc Los Huertos and Felicia Rein, from the University of California – Santa Cruz, concluded that grassland "…buffer strips are very effective for erosion control and sediment capture, both sediments and chemicals, and both historic and present." In addition, according to the Natural Resources Conservation service, conservation buffers slow water runoff, trap sediment, and enhance infiltration within the buffer. Buffer strips are also known to trap fertilizers, pesticides, pathogens, hydrocarbons, and heavy metals, and reduce blowing soil in areas with strong winds. Since it was determined that the restoration of a 500-foot wide wooded riparian corridor was not possible, resource specialists decided that adding a native grassland buffer component to the outside edges of the riparian corridor, where possible and practical, would help to improve the filtering of sediments and pollutants, including heavy metals, hydrocarbons, pesticides, fertilizers, pathogens, etc., improve the infiltration rate in the area, and help to buffer the wooded habitat from noise, and surrounding land use activities and human disturbance, thereby increasing the quality of the riparian habitat. The benefits of this grassland buffer are considered especially valuable in urban areas where there are multiple sources of point

and non-point sources from runoff. Two different widths of native grass buffers, 50 feet and 100 feet, were retained as restoration measures –.

Grasslands – Grasslands and Tree Mottes Combination (Measure 6). According to Diggs et. al (1999), the presettlement condition of the Grand Prairie was largely a vast grassland, with woodlands found only as narrow ribbons of bottomland stands along the major watercourses, as scattered mottes in the prairie grasslands, or associated with draws and drainages of upland mesas and buttes. The addition of tree mottes with native grassland restoration would again mimic historic ecosystem conditions, while incorporating an additional component of bottomland hardwoods to the floodplain. To further mimic natural conditions and not impede flood flow, these mottes would be established in random patterns, irregular in shape, relatively small, one-half to two acres in size, and be established in dense patterns to provide protective cover for hiding and reproduction. Hydrologic and hydraulic modeling indicates that the non-uniform scattering of tree mottes and/or planting narrow linear strips of bottomland hardwoods that run parallel to the river channel would be most efficient in helping to maintain flood conveyance in the study. This measure was retained for those areas where reforestation was precluded by the hydraulic constraints and no other restoration measures were specifically identified. A generic habitat gain and cost per acre were developed for this measure and utilized in its consideration during the incremental analyses.

Grasslands – Improvement of Native Prairie Grasslands (Measure 7). As was noted in the existing conditions descriptions in Chapter 2, the Tandy zone includes relics of the historic Fort Worth Prairie that once covered much of the region. The presence of this native prairie was indicated by the presence of little bluestem in composition with Indian grass, big bluestem, and switchgrass with small numbers of other common grasses and numerous species of forbs. The value of this prairie habitat is quickly deteriorating due to the invasion of woody species, such as eastern red cedar and mesquite, and erosion problems caused by human induced disturbances. Not only is the modification of this habitat type of grave concern to resource specialists because it is extremely rare (less than 1 percent of the native tallgrass prairies that were once found in Texas prior to settlement remain), but its value to wildlife and bird species is also being diminished, as is the diversity of the plant and animal species this prairie once supported. One of the measures being evaluated is the improvement of this native grass prairie by removal of the invading woody species that, if left unchecked, will eventually modify the prairie grasslands to low quality shrublands. Three alternative methods for doing this were considered by the study team – prescribed fire, mechanical removal, and hand removal. Prescribed burning was eliminated for safety reasons, because of the proximity of several residential structures to the prairie grasslands. Mechanical removal was also eliminated because of the fragile nature of thin soils and grassland vegetation, which is very susceptible to disturbances. Therefore, hand removal of the invading woody species was the restoration measure included in further analysis.

AQUATIC HABITAT. Restoration measures that would create and improve aquatic habitat in the study area would help to address several of the planning objectives, including restoring a more natural hydrologic regime; restoring and improving aquatic habitat for fish and other aquatic organisms; providing a sustainable level of food, nesting, and cover for all wildlife communities; restoring the stability, function, and dynamic

processes of the floodplain to a more natural, less degraded condition; protecting and increasing habitat diversity and the interspersion of habitat types; and improving the water quality in conjunction with other ecosystem restoration activities.

Aquatic Habitat Improvements – Reconnect Oxbow to Flowing Water (Measure 8A1). There are numerous opportunities to restore aquatic habitat in the Riverside Oxbow study area. A major opportunity is to reconnect the oxbow to the modified channel and provide flowing water through the system. The oxbow has been physically disconnected from the river at both ends by construction of the flood diversion channel. The only water that enters the oxbow is from local runoff following rain events, overbank flooding during flood events, or backwater from the West Fork that enters at the downstream confluence of the oxbow with the river channel. In typical summers, it isn't unusual for portions of the oxbow channel to be dry, particularly in the upstream end, which isn't often influenced by backwater from the West Fork. Other portions of the channel become shallow stagnant pools. Neither of these conditions is beneficial to the value of the aquatic habitat. Providing flow through the oxbow would serve to improve the aquatic habitat in the area because it would help reduce stagnation of water in the channel, improve dissolved oxygen levels and reduce the quantity of anaerobic sites, improve benthic habitat, provide inflow and outflow of nutrients and food sources, and help to lower the water temperature and provide a more consistent temperature regime.

In order to restore the hydraulic connection of the oxbow to the river (upstream end of the oxbow), the study team identified two means of opening flow between the oxbow and the modified channel. The options are to construct a culvert through the existing earthen plug or to remove the earthen plug altogether. These measures are shown in Figure 7. Either would allow water to flow from the modified channel into the oxbow, however, construction of the culvert would limit water flow to relatively low flow conditions, while the removal of the earth plug would allow for periodic flush flows during flood events on the West Fork. Accordingly, there are differences in the environmental benefits gained. Both measures are carried forward in the analysis.

In addition to the problem of how to reconnect the oxbow to the modified channel, there are other existing hydraulic problems in this reach that need to be addressed, both from an environmental standpoint and that of hydraulic feasibility. Opening only the upstream end of the oxbow to through flows is problematic. Additional problems include the downstream barrier at Beach Street and the need to provide some type of hydraulic control to avoid draining the water impounded in the modified channel. These additional problems are discussed below as measures 8A2 and 8A3, respectively.

Aquatic Habitat Improvements – Modifications at Beach Street (Measure 8A2). The Beach Street crossing of the oxbow channel consists of an earthen dam through which a culvert has been placed. This concrete culvert is approximately 12-feet in diameter and 245 feet long (see Figure 8). During current high water conditions, the culvert is inadequate to pass flows causing water to overtop the channel banks. This problem would be exacerbated once the upstream end of the oxbow is reconnected to the river. During low flow

conditions, water stagnates in front of the culvert opening and does not flow into the culvert. This culvert also has a downstream invert that is higher than the existing ground surface elevations, resulting in water dropping several feet into the channel bottom during those occasions when water actually flows through the culvert. This hydraulic drop scours the channel and surrounding banks. Resource specialists noted that this scouring effect is destabilizing the bank along the roadbed of the turning lane for Gateway Park. In addition, during significant flow conditions, the drop pool becomes an eddy pool and, as water levels recede, debris is deposited along the banks at this site. The culvert also serves as a barrier to movement of species such as raccoons, opossum, rabbits, beaver, snakes, turtles, fish, and amphibians. Heavy traffic on Beach Street results in numerous road kills at the crossing. Figure 9 shows a lengthwise cross-section of the Beach Street culvert in relationship to the oxbow channel bottom.

The study team evaluated two measures for opening flows through Beach Street. One would be to replace the existing culvert with a box culvert that is set at a lower elevation at the same grade, which would help relieve the constriction and temporarily relieve the downstream scour. Over time it is anticipated that scouring would continue and debris would again collect. In addition, the length of the culvert would still serve as a barrier for movement of aquatic and terrestrial wildlife. The other measure evaluated was removal of the culvert at Beach Street to open the channel for flow and construction of a bridge that would span the channel, allow for planting of vegetation along the channel, and free movement of aquatic species in the channel and wildlife species along a riparian corridor between Oxbow North and Gateway Center and Gateway South. Both measures are carried forward for further analysis

Aquatic Habitat Improvements – In-channel weir (Measure 8A3). In addition to establishing a hydraulic connection to the river at both the upstream and downstream ends of the oxbow, implementation of some type of weir, or hydraulic control structure, is necessary to control the amount of water diverted from the modified channel into the oxbow during low flow conditions. This prevents potential adverse environmental impacts to the modified channel caused by draining the water impounded by the low water dam downstream of Beach Street (see Figure 9). The study team investigated and evaluated three locations for this weir. The first of these sites is at the upstream end of the oxbow channel where it meets the modified channel. The second location evaluated was at Beach Street. The final location evaluated for the in-channel weir was near a newly constructed pedestrian bridge just upstream of the confluence of the oxbow with the West Fork.

Besides providing hydraulic control, the location of an in-channel weir at either Beach Street or upstream of the confluence has the potential to provide additional aquatic habitat benefits, riparian terrestrial habitat benefits, and wetland habitat benefits by wetting a greater width and length of the oxbow during critical low flow periods. Diversion of water from the modified channel to the oxbow could provide flow of approximately 2 to 3 cubic feet per second during the 7-day 10-year low flow. This flow, while sufficient to reduce stagnation problems in the channel, is insufficient to wet the channel bottom perimeter. The hydraulic control would maintain the wetted perimeter necessary to maintain fisheries, benthic invertebrate production, and important habitat interface between the aquatic and terrestrial environment. On the negative side, the construction of an in-channel weir could impede the

movement of aquatic species along the channel. The study team worked to design a structure that is friendly for aquatic species movement and is as natural looking as possible. Some of the design features include notched spillways across the top of the structure, which

Figure 7

Figure 8

Figure 9

will allow water flow under most conditions. The structure would also be designed to allow overtopping during high water conditions, which will allow the free movement of aquatic species at those times. Figure 8 shows a conceptual drawing of what the in-channel weir would look like upon implementation. All three siting options for the weir were carried forward for further analysis.

Aquatic Habitat Improvements - Boulder clusters (Measure 8B). By restoring flow through the oxbow, it is anticipated that the stream will once again take on many of the characteristics of a natural stream channel, more closely reflecting the historical aspect of the oxbow prior to the construction of the modified channel. This includes the formation of pools and riffles. Pools and riffles are associated with the thalweg, which will meander within the channel once flow is restored. Pools will typically form in the thalweg near the outside banks of bends and riffles in the straight portion of the channel where the thalweg crosses over from one side of the channel to the other. By opening the oxbow to flow, both periodic flood flows and low flow conditions, will, over time, remove the sediment build up within the oxbow channel that has collected since flows were cut off, and reestablish a natural riffle/pool complex. The addition of three series of boulder clusters placed in the base flow channel will help to provide cover and improve substrate, create scour holes, and areas of reduced velocities, all of which will add to habitat diversity, including spawning sites for fish species, shelter and structure for benthic invertebrates, improved habitat space and quality for aquatic invertebrates, and additional in-stream aeration. The careful placement of boulders clusters could also be used to protect the channel banks from erosion in potential problem sites. The exact locations of the boulder clusters would be determined after the oxbow is reconnected to the river and the channel has time to revert back to a natural riffle/pool system. The boulder cluster measure was retained for evaluation in combination with each measure to reconnect the oxbow to the river.

EROSION CONTROL (Measure 9). An additional problem identified is that of erosion and sediment transport, especially in the Tandy zone where the slopes are covered by a relatively thin layer of soil and vegetation that is easily damaged. Most of the erosion appears to be the result of illegal usage of the area by off road vehicles and random pedestrian hiking and biking trails, which have damaged the vegetation that helps to stabilize the slopes. In addition, the zone includes the site of a failed restaurant, which was once located on top of a hill between Tandy Hill Park to the east and the private residential lands to the west. The building has been removed, but considerable disturbance in the form of the slab, parking lots, and bulkheading remains. These areas of damaged vegetation provide locations for runoff following rain events. This runoff washes additional soil and vegetation from the slopes further exacerbating the problem and, over time, the soil on these slopes sloughs off and the problem magnifies. The existence of numerous riparian fingers with associated draws and rivlets in this zone that directly connect to the West Fork of the Trinity through a series of culverts under IH-30 mean that this soil quickly makes its way into the river causing increased sedimentation and turbidity and reducing the quality of the aquatic habitat. There are signs of major sediment deposition occurring in the river channel just downstream of one of the culvert outfalls connecting the Tandy zone to the West Fork of the Trinity River. The slope erosion also diminishes the terrestrial wildlife habitat value of the area. Bioengineering techniques and soft solutions are the preferred measure to stabilize the slopes, place topsoil, as needed, and replant the areas with native grasses. This

restoration measure was exclusive to the West portion of the Tandy zone and it was included in an interim analysis for the Tandy zone in combination with measures involving acquisition of the Tandy West property.

WOODLAND UNDERSTORY IMPROVEMENTS (Measure 10). The floodplain lands along the rivers and creeks and in the bottomlands of the study area are comprised of Frio soils, as are most of the floodplain lands in the Upper Trinity River Basin. Historically, the climax plant community for the Frio soil is mid- and tall-grasses with a tree canopy of pecan, elm, bur oak, and cottonwood. Currently, there is an invasion of non-native woody species, such as privet, occurring in the understory of the bottomland hardwoods in the Tandy zone. There are many wooded stands, especially on the eastern side of the Tandy zone, in the Tandy Hills parklands where the only native vegetation to be found is the canopy trees. Not only has this caused a loss of habitat quality and diversity within this zone, but the transportation of seed sources from the non-native invasive plant species in this area poses a significant threat to the other zones within the study area and to the terrestrial and aquatic habitat of the lands along the West Fork downstream of the Tandy zone. This restoration measure was exclusive to the East portion of the Tandy zone and it has been included in an interim analysis for the Tandy zone in combination with acquisition of the Tandy East property.

FENCING (Measure 11). As was described in the Erosion Control section above, most of the erosion occurring in the Tandy zone appears to be the result of illegal use of the area by off road vehicles and random pedestrian hiking and biking trails which have damaged the vegetation that helps to stabilize the slopes. One of the restoration measures evaluated by the study team for the Tandy zone includes limiting assess to the zone by fencing the boundaries using a post and cable fencing system. This restoration measure was exclusive to the Tandy zone. It has been included in an interim analysis in combination with acquisition of Tandy zone property of any scale.

SUMMARY – ECOSYSTEM MEASURES AND SCALES

The section has described the restoration measures and scales developed by the study team to improve habitat values within the study area. A relatively large number of measures and scales were identified. For clarity purposes, Table 8 displays a list of all the restoration measures identified for the study area and gives the number of the page, or pages, where the measure is discussed in more detail.

RESTORATION MEASURES BY ZONE

Plan formulation was undertaken to address identified problems by project zone, starting in the oxbow area. Most of the Riverside Oxbow study area is within the 100-year floodplain of the West Fork of the Trinity River and contains similar assemblages of vegetative habitat types. Formulation and evaluation of measures by habitat type in the oxbow zones (North,

Center, and South) were therefore applied to similar habitat types in the Gateway zones (Center, South, Beach, Park, and East).

The following paragraphs describe the formulation and evaluation of restoration measures and/or scales of measures for each of the zones within the study area to meet the planning objectives, relative to the "without project" condition. As noted earlier in this chapter, real estate costs have been incorporated into the annualized costs of restoration measures, except for the Tandy zone where the study team evaluated several different acquisition sizes. All other measures identified in Table 8 were applied, as applicable, to the problems identified for each of the study zones.

Oxbow North. The Oxbow North zone includes the cutoff oxbow channel between Riverside Drive and Beach Street, which is approximately 1.3 miles in length, its associated riparian corridor, an adjacent ponded area just upstream of Beach Street, the lands around the ponded area, and a small parcel of land between Riverside Drive and the upstream end of the cutoff channel.

During existing conditions investigations, several problems specific to the quality of the habitat were noted within the Oxbow North zone. These include: 1) the narrow width of the wooded corridor; 2) gaps within and between wooded tracts; 3) a lack of hard- and soft-mast producing trees and shrubs; 4) a lack of cavity trees in the existing wooded tracts for brood rearing and nesting; 5) understory vegetation in some tracts that is too dense or comprised of non-native vegetation species; 6) the lack of water flow through the oxbow which results in an alternate series of stagnant pools and areas of dry channel; 7) adjacent land use activities to the north that could adversely impact water quality parameters in the oxbow and the quality of the riparian corridor habitat; and 8) a culvert at Beach Street, which functions improperly during both high and low flow conditions and which blocks the safe migration of wildlife species along the riparian corridor and aquatic species within the channel.

An additional constraint identified in this area is a site north of the oxbow that has been contaminated by hydrocarbons. This site was brought to the attention of the Fort Worth Environmental Department because of the discovery of hydrocarbon contamination in the soil during the installation of a sewerage line about three years ago. At that time, actions were taken to avoid the contamination during the construction of the sewer line and the project was completed. The site was not remediated and the hydrocarbons remain in the soil. The city's Environmental Department provided the study team with a map of the area delineating the extent of contamination, but questions remain as to the extent of the contamination. Rather than incur the costs associated with a costly and lengthy HTRW investigation and remediation effort at this time, it was determined that the site and surrounding lands would be removed from further consideration for restoration efforts as project lands. Reduction in study area size by 6 acres in this zone ensures that the site is avoided and provides a conservative buffer around the site to protect against potential future impacts to project lands.

Oxbow Center. This zone is bordered on the west and north by the Oxbow North zone, on the east by Beach Street, and on the south by the modified channel. Approximately

124 acres in size, this zone is predominately grasslands. A partial remnant channel of Sycamore Creek holds local runoff for short periods of time each year providing a small seasonal wetland. There are several large individual pecan and bur oak trees scattered along the edges of the abandoned Sycamore Creek channel in this zone.

During existing conditions investigations, problems specific to the quality of the habitat within the Oxbow Center zone were identified. These include: 1) the lack of bottomland hardwoods, with the exception of the few scattered pecans and oaks; 2) the relatively poor quality of the grassland habitat, which is comprised mostly of coastal Bermuda and Johnson grass; 3) the ephemeral nature of the existing small wetland which has little habitat value; and 4) the existence of several acres of disturbed soils which have no habitat value.

Another constraint to potential restoration opportunities in the zone is the location of site identified by the city of Fort Worth for future development of an outdoor soccer facility. The site in question is located in the north central region of the zone. Because the location of the facility would not adversely impact the creation of the wetland complex and the proponent for the facility expressed their willingness to meet certain guidelines for such items as directional lighting; the limited use of fertilizers, herbicides, and pesticides; the design and specification of fencing materials; and the operations and maintenance of the facility; it was determined that construction and operations of the soccer complex would not adversely impact the value of the surrounding habitat. For this reason, the site has been removed from further consideration for restoration efforts or inclusion in the project study area. The removal of this site from the Oxbow Center study area reduces the acreage in the zone to 85.1 acres and reduces the existing wildlife habitat value to 54.4 habitat units.

A final constraint to restoration opportunities in this area is the finding of a buried cultural site near where Sycamore Creek once confluence with the original West Fork channel. The location of the small outlet channel from the wetland complex to the oxbow channel needs to be configured to avoid adverse impacts to a prehistoric cultural resources site.

Table 8
Ecosystem Restoration Measures and Scales Evaluated

#	Measures	Scales	Comments
	Acquisition	Incorporated in restoration costs.	p. 66
1	Reforestation of bottomland hardwoods		
		A - Extent	Capped at 10 percent; see pp. 67-68
		B – Corridor width	100 meters; see p. 69
		C – Density and planting materials	40 1-inch caliper containerized trees, 20 1-gallon containerized shrubs and 150 seedlings per acre; see ICA pp. 69-71
2	Improvements to existing bottomland hardwoods	Density	5 1-inch containerized trees, 5 1-gallon containerized shrubs, and forest management (thinning, etc.) per acre pp. 70-71
3	Creation of wetland complexes		
		A – Size	5.1-, 12.3-, or 17.8 acres in Oxbow Center; pp. 66-67 and 15.0-, 26.8-, or 35.0 acres in Gateway East, p. 72-73
		B – Wetlands plus water control and wetland plantings	p. 73
		C – Wetlands with water control and wetland plantings plus water supply	Permanent pumping station; pp. 74-75
4	Improvements to existing wetlands		
		A – Recontouring	p. 74
		B – Recontouring plus water control and plantings	p. 75
		C – Recontouring with water control and plantings plus water supply	p. 75

Table 8, continued.

#	Measures	Scales	Comments
		D – Recontouring with water control, plantings, and water supply plus removal of old Gateway Park road	pp. 75-76
		E – Adding water control structure	p. 76
5	Grassland buffer strip along riparian corridor		
		Size	50 or 100 meters in width; p. 77
6	Grasslands and tree motte combination	Yes/No	p. 77
7	Restoration of native prairie grasslands	Yes/No	p. 78
8	Aquatic habitat improvements		
		A 1 – Reconnect - upstream	
			Culvert; p 79
			Remove plug; p. 79
		A 2 – Reconnect - downstream	
			Replace culvert with box culvert; p. 79
			Replace culvert with bridge; p. 79
		A 3 – In-channel weir	
			Located at upstream end of oxbow; p. 80
			Located near Beach Street; p. 80
			Located near downstream confluence of oxbow and the West Fork; p. 80
		B – Boulder clusters	p. 80
9	Erosion Control		
			Repair slope, add topsoil, and plant native vegetation; pp. 80-81
			Remove slab and parking, repair slope, add topsoil, and plant native vegetation; pp. 80-81
10	Woodland understory improvements	Yes/No	p. 81
11	Fencing	Yes/No	p. 81

Oxbow South. The Oxbow South zone includes the area along the south and east banks of Sycamore Creek between IH-30 and the channel and a broader area between the modified channel and IH-30 extending from the west bank of Sycamore Creek to Riverside Drive. A parcel of land just west of Beach Street was not included in the study area within this zone because of the presence of a church. This zone also includes the confluence of Sycamore Creek with the modified channel, a low water dam downstream of Beach Street, and an existing 3.1-acre wetland.

During existing conditions investigations problems specific to the quality of the habitat within the Oxbow South zone were noted. These include: 1) the lack of bottomland hardwood stands limit this site's value to native and migratory wildlife and avian species; 2) the relatively poor quality of the grassland habitat, which is comprised mostly of Bermuda grass and Johnson grass; and 3) the noise from the adjacent IH-30.

Besides the constraints established by the CDC and ROD criteria for the overall Riverside Oxbow study area, which helped determine what types of restoration options are viable in this zone, two other constraints have an impact on the restoration opportunities in the Oxbow South zone. Representatives of the Tarrant Regional Water District advised the study team that there was a verbal commitment between TRWD and the congregation of the church that occupies a parcel of land just west of Beach Street adjacent to the Oxbow South zone. The agreement was for TRWD to allow the church to use lands owned by TRWD located west of the church to 50 feet east of Sycamore Creek in exchange for the church giving TRWD control of a 50 foot wide swath of land owned by the church from the top of the bank on the south side of the modified channel. The church has expressed its intention of using the land currently under TRWD ownership for a baseball and softball field and recreation area. The study team therefore determined that these lands would no longer be available for restoration and they would be removed from potential project lands, leaving 28.7 acres available for restoration.

Gateway Center. This reach is located in the area immediately downstream of the Beach Street crossings of the modified channel and the remnant oxbow channel. It is a triangular-shaped tract of land that contains low quality woodlands, highly manicured grasslands, and about 7.6 acres of disturbed lands. The location of the zone provides an important link between upstream resources and those associated with the riparian forest located downstream. Ecosystem restoration efforts in this zone have the potential to be not only highly beneficial to this site, but, as an integral link, could provide positive cumulative benefits to the upstream and downstream reaches.

During existing conditions investigations, resource specialists noted problems specific to the quality of the habitat within the Gateway Center zone. These include: 1) the lack a contiguous riparian corridor along the south side of the oxbow; 2) the low quality of the existing bottomland hardwood stands; 3) the low quality of the maintained grasslands; 4) the abundance of disturbed lands which supply no habitat value; and 5) the location of a rundown wooden pallet manufacturing facility located in a small parcel of land along Beach Street which serves as an eyesore in the area and has adverse impacts on the habitat value of surrounding resources.

Gateway South. This study zone encompasses the Gateway Center zone to the north and south across both the oxbow channel and the modified channel. North of the oxbow, the zone generally includes the bottomland hardwood corridor located between Beach Street on the west, the park entrance road to Gateway Park on the north, and the first river bend below the confluence of the oxbow with the West Fork on the east. South of the modified channel the zone includes mostly grasslands from Beach Street on the west, the modified channel on the north, IH-30 on the south, and the first river bend below the confluence of the oxbow with the West Fork on the east. Much like the Gateway Center zone, this zone has linkages to all components of the oxbow and all components of Gateway Park. Ecosystem restoration efforts in this zone, as an integral link, could provide positive cumulative benefits to the upstream and downstream zones.

Problems noted specific to the quality of the habitat within the Gateway South zone include: 1) gaps within the riparian corridor along the north side of the oxbow; 2) a lack of hard- and soft-mast producing trees and shrubs in existing wooded tracts; 3) a lack of cavities trees in the existing wooded tracts for brood rearing and nesting; 4) understory vegetation in some tracts that is too dense or comprised of non-native vegetation species; 4) the low quality of the maintained grasslands; and 5) traffic noise from IH-30.

In addition to the CDC constraints, this zone has been identified for channel and overbank modifications to mitigate for the rise in surface water profiles as a result of planting additional bottomland hardwood forest stands in the 100-year floodplain in other project zones. Mitigation efforts would require the removal of approximately 100,000 cubic yards of material along the south bank of the channel and in the overbank area in this zone. It was determined that the river bank downstream of the low water dam would be cut back up to 50 feet and the top of bank graded to resemble a natural overbank terrace. Material would be cut out behind the terrace in the existing grasslands to simulate a wet meadow restoration. USFWS and TPWD concur that this area of hydraulic mitigation currently provides no environmental value and does not require environmental mitigation. Conceptual plans for this design are included in the Civil Design appendix of the feasibility report. The final design details would be undertaken during plans and specifications of the project once all the restoration designs and specifications are completed and a final hydrologic model developed for projected project conditions.

Gateway Beach. This zone includes approximately 160 acres of land east of Beach Street, north of the entrance road to Gateway Park off of Beach Street, and east to Gateway Park. The area, which has been heavily disturbed by past activities, is generally grasslands (mostly bermudagrass), which provides low quality habitat, with a component of low quality woody vegetation located around some existing ponds and wetlands, and approximately 47 acres of disturbed soils, as a result of fill activities.

Specific problems related to the quality of the habitat within the Gateway Beach zone include: 1) large acreage of disturbed land with no habitat value; 2) low quality of the existing grasslands which make up the large portion of the zone; 3) the low quality of the aquatic habitat in existing ponds and wetlands; 4) the proliferation of non-native shrubs around the

higher banks of the largest wetland which greatly reduces wildlife habitat values; 5) a lack of hard and soft mast producing trees and shrubs in the existing forested habitat around the wetlands; 6) a lack of snags and cavities for use as brood rearing and nesting sites; 7) a lack of a reliable water source for the wetlands areas; 8) the lack of contours and terraces in the existing wetlands that limit the quality and quantity of wetland habitat; 9) the location of the park entrance road off of Beach Street which serves as a barrier to a natural hydraulic connection between the wetlands in the zone and the oxbow to the south; and 10) Fort Worth's Recreation Master Plan for the existing and potential future lands within and adjacent to Gateway Park which identifies some portions of the zone for future intensive recreation development actions.

The constraints identified in this zone, in addition to the CDC criteria, are other Section 404 permitted activities and their associated hydraulic and hydrologic mitigation requirements. Originally, gravel and soil mining activities in the area resulted in the creation of several ponds and wetlands. Some of these wetlands and ponds were subsequently filled under Section 404 permit conditions issued in November 1987. In addition to filling some of the ponds and wetlands, the ground elevation in a portion of the zone was raised out of the 100-year floodplain by these fill activities. Gravel and soil mining activities resulted in the creation of several ponds and wetlands, some of which were subsequently filled under Section 404 permit conditions issued in November 1987. The filled portion of the zone has largely reestablished a grass cover; however, Bermuda grass, which provides low quality habitat conditions, dominates. Although no pads or buildings have been constructed on the fill, future without project conditions indicate that little additional filling would be required to make the portion of the tract that fronts Beach Street a highly desirable location for commercial development. As mitigation for fill activities, a small wetland area was contoured to connect to one of the residual lakes and a little bank sloping was conducted to foster some moist soil development. These areas provided adequate mitigation for the past filling activities; however, substantial improvements could still be implemented to provide substantially greater fish and wildlife habitat benefits.

Finally, representatives of the Fort Worth Parks and Community Services Department provided the study team with a map delineating the location of future recreation development activities as identified in their recently completed and approved Gateway Park Recreation Master Plan. The Master Plan and map depicts planned future recreation development on existing and potential future lands within and adjacent to Gateway Park. According to the master plan, some of the lands located in the Gateway Beach zone along East 1st Street are slated for future recreation development. Based on this, the study team decided to remove these lands, roughly 22 acres, from further consideration for restoration efforts.

Gateway Park. This zone includes all the lands south of East 1st Street between Gateway Beach and Gateway East. The majority of these lands, approximately 120 acres, are maintained grasslands with about 68.6 acres of woodlands and 68.4 acres of disturbed areas. The disturbed areas include the old wastewater treatment facility, existing softball fields and associated parking lots, and park access roads.

Currently, most of the lands within this zone are either being utilized for intensive recreation activities, i.e. soccer fields, softball fields, rugby fields, etc., or are slated for future use as intensive recreational activity sites. The exception to this is the parcel of land and the facilities associated with the old wastewater treatment plant. At this time, the city of Fort Worth is not interested in pursuing the demolition and removal of the structures in this area and analysis and probable clean up of this site to make it usable for recreation or restoration purposes. Given the current and proposed future usage of the lands within this zone for intensive recreational activities, the study team determined that the lands within this zone should be removed from further consideration for ecosystem restoration opportunities.

Gateway East. This study reach extends downstream of the Gateway Center and east of the Gateway Park zone to the East 1st Street bridge. The zone contains about 139 acres of lands, consisting of 97.01 acres of riparian forest, 0.72 acres of water, 5.62 acres of wetlands, and 34.94 acres of grassland. Only 0.43 acres of disturbed soil was identified.

Problems specific to Gateway East zone include: 1) areas with a narrow riparian corridor, especially in the western portion of the zone; 2) a lack of hard- and soft-mast producing trees and shrubs in some of the existing wooded tracts; 3) a lack of cavities trees in the existing wooded tracts for brood rearing and nesting; 4) understory vegetation in some tracts that is too dense or comprised of non-native vegetation species in some areas; 5) areas disturbed by past use as drying beds in waste water treatment processing; and 6) an old oxbow remnant of the West Fork no longer connected to the river channel except during periods of high flows.

There are two constraints applicable within this zone, the CDC constraints and contamination of sediment in the drying beds of the abandoned wastewater treatment plant. As noted previously, the CDC constraints have been accommodated in the definition/development of the reforestation measures. The city of Fort Worth has indicated that they are working with the Texas Commission on Environmental Quality to develop a clean closure plan for the drying beds and will take responsibility for cleaning up the site prior to the lands being acquired for inclusion in the proposed ecosystem restoration project. The USFWS is reviewing the city's site report and will monitor clean up activities to ensure that there is no potential to adversely impact wildlife and avian usage of the area in the future.

Tandy. The Tandy zone contains about 160 acres of mixed grassland, shrubland, and trees over a highly diverse terrain. Vegetation analysis identified roughly 60 acres of woodlands, 90 acres of grasslands, and at least 8 acres of disturbed lands; however, it is believed that the amount of disturbed soils have more than doubled since the date the imagery was captured. Less than one acre of moist soils associated with the many small rivlets originating on the hillsides was identified. The entire site is unique within the area due to the diverse topography and the presence of a relic native prairie that is slowly being modified due to human disturbances and changes brought about due to control of wildfire that historically helped maintain prairie areas.

Problems specific to the Tandy zone include: 1) invasion of the grasslands from eastern red cedar, mesquite, and other woody species which is degrading the value of the prairie habitat; 2) proliferation of non-native species, such as privets, invading the understory of the wooded riparian stringers, especially in the Tandy Hills Park portion of the zone; 3) erosion problems on the slopes which are contributing to sedimentation and water quality problems and reducing aquatic habitat in the West Fork river channel downstream of the outfalls from the Tandy zone; 4) disturbance from a failed restaurant including the remnant foundation slab, parking lot, and slope bulkheading; 5) trash dumping and illegal off-road vehicle usage of the area, which adversely impacts the vegetation and causes erosion; 6) transportation of light seeds from invader species vegetation in this zone poises a significant threat to the entire study area and areas downstream along the West Fork of the Trinity; and 7) the loss of habitat and species diversity and population numbers as a result of human-induced modifications to the vegetation composition.

As noted in the existing conditions discussion of the Tandy zone in Chapter 2, the construction of IH-30 on a raised bed serves as an impediment to the physical and natural ecosystem connections between the Tandy zone and the river channel and other zones within the study area, but has not severed the interconnectedness of the zone from the riparian corridor. Site reconnaissance during the existing conditions investigations have shown that the highway has not stopped adverse impacts to the river channel from increased sediment loading as a result of slope erosion in the Tandy zone. In addition, the highway doesn't serve as a barrier to avian species that are known to utilize both the Tandy zone and the riparian corridor in the other zones. The transport of seed sources from light-seeded non-native vegetation from the Tandy zone is occurring as a result of the prevailing winds, bird droppings, and runoff following rain events. The proximity of the Tandy zone to the other zones in the study area makes it even more important to remove the source of non-native vegetative species which unless controlled would ultimately result in increased operation and maintenance costs of the other areas of project.

Benefits that could be obtained from restoration of this zone would predominantly occur on lands outside the 100-year floodplain, which traditionally has not been a high priority for USACE restoration efforts; however, the proximity of the site and the potential for degradation of the site to have adverse impacts on the higher priority resources associated with the West Fork of the Trinity River should be considered.

As part of the plan formulation and evaluation process, all benefits and adverse contributions of applicable restoration measures and scales, were compared to existing conditions, as described and summarized in Chapter 2, and future without project conditions.

Less than half of the lands within the study area are owned by public or quasi-public entities. While a majority of the lands within the study area might be protected from development due to their location within the 100-year floodplain, the management of the lands, even those in public ownership, leaves them vulnerable to uses that are not compatible with quality wildlife habitat.

Various tracts of land between the oxbow and the modified channel have multiple owners. Until a few years ago, a majority of the land was leased for hay production. Now it is maintained by the TRWD who generally mow it several times a year. During site reconnaissance in the summer of 2001, fill activities were observed in the remnant scar of the old Sycamore Creek channel located in the Oxbow Center zone. Since construction of the modified channel, this low lying area has been a shallow, ephemeral wetland, whose sole water source is localized runoff and periodic overbank flooding along the river channel. Because it is typically dry for so much of the year, this wetland has little value as wetland habitat, but even that value would be lost through further fill activities.

It is anticipated that much of the riparian habitat still existing along the northern edge of the old oxbow would be cleared in the future to accommodate storage and stockpiling activities associated with the various commercial and industrial uses in which the owners are engaged. The private lands along the east side of Beach Street would likely be developed for commercial businesses. Other lands within Gateway Park itself and already owned by the city of Fort Worth, would be vulnerable to future active recreation uses that would virtually eliminate any of their value for wildlife habitat. Even the habitat value of the lands located within the Tandy Hills area, whose topography generally renders it inviolate to development, would decrease in the future as the lands are further damaged by off road vehicle use and invasion of exotic plant and tree species.

MEASURES CONSIDERED BY ZONE

The previous narrative described the restoration measures and scales applied to various zones in the study area. Some of the restoration measures are utilized in more than one zone and some of the measures impact more than one zone. Tables 9 displays the zones where the restoration measures were considered for implementation and any other zones that would be directly affected. Table 9a displays the restoration measures that were considered for each zone in the subsequent Incremental Analysis and Cost Effectiveness analysis.

Table 9
Zones Considered and Zones Affected by Restoration Measures

Measure #s	Zones Considered	Zones Affected
1	OXN, OXS, GWC, GWS, GWE	OXN, OXS, GWC, GWS, GWE
2	OXN, OXS, GWC, GWS, GWE	OXN, OXS, GWC, GWS, GWE
3	OXC, GWE	OXC, GWE
4	GWB, OXN, GWE	GWB, OXN, GWE
5	OXN, OXS, GWC, GWS, GWE	OXN, OXS, GWC, GWS, GWE
6	OXN, OXC, OXS, GWC, GWS, GWB	OXN, OXC, OXS, GWC, GWS, GWB
7	TD	TD
8	OXN, GWC	OXN, GWC, GWS
9	TD	TD
10	TD	TD
11	TD	TD

OXN – Oxbow North, OXC – Oxbow Center, OXS – Oxbow South, GWC – Gateway Center, GWS – Gateway South, GWB – Gateway Beach, GWE – Gateway East, TD – Tandy.

.

Table 9a
Restoration Measures considered by Zone

Zone	Measures Applied
Oxbow North	1, 2, 4, 5, 6, 8
Oxbow Center	3, 6
Oxbow South	1, 2, 5, 6
Gateway Center	1, 2, 5, 6, 8
Gateway South	1, 2, 5, 6
Gateway Beach	3, 6
Gateway East	1, 2, 3, 4, 5
Tandy Hills	7, 9, 10, 11

1 – Bottomland Hardwood Reforestation, 2 – Bottomland Hardwood Management, 3 – Creation of Wetlands 4 – Improvement of Wetlands, 5 – Grassland Buffer Strips, 6 – Grassland/Tree Mottes, 7 – Native Prairie Restoration, 8 – Aquatic Habitat Improvement, 9 – Erosion Control, 10 – Wooded Understory Improvements, 11 – Fencing

The USFWS Habitat Evaluation Procedures (HEP) were used to quantify the habitat values within each study area zone under existing conditions and for each ecosystem restoration measure applied to each zone as summarized in Tables 9 and 9a of this chapter. The Habitat Unit outputs, along with the costs of the various measures were input to the IWRPlan model, which generates incremental analysis and cost effectiveness outputs for each measure for each zone. The output data from IWRPlan are included in this report as an Addendum to Appendix E. Rather than displaying the HEP data for all measures for all zones, an example for habitat type is presented below.

EXAMPLE SUMMARY OF INCREMENTAL ANALYSIS STEPS FOR OXBOW CENTER.

Under existing project conditions, the acreage in Gateway South was 138.72 acres. Table 10 displays acres, existing conditions HSI value, , and the computed number of habitat units of each habitat type in the zone under existing conditions.

Table 10
Gateway East Summary of Habitat Units – Existing Conditions

Water		Wetlands		Forest		Grassland		Disturbed	
Acres	HSI	Acres	HSI	Acres	HSI	Acres	HSI	Acres	HSI
0.72	0.4	5.62	0.38	0.97.01	0.64	34.94	0.13	0.43	0
HUs – .29		HUs – 2.13		HUs – 62.09		HUs – 4.54		HUs – 0	

Therefore, the total number of habitat units for the zone under existing conditions equals 69.05.

The next step is to annualize the habitat units for the future without and future with project, or with measure, conditions over the 50 years life of the project.. The future with project conditions are calculated separately for each of the restoration measures considered for the zone. Table 11 displays the results of the annualization for future without project conditions for each restoration measure considered in the zone.

Table 11
Habitat Unit Annualization Summary for Oxbow Center

Measure	TYO (Current) HUs	Year 1 HUs	Year 10 HUs	Year 50 HUs	Average Annual HUs
Future Without Project	69.05	68	65	60	63.48
Contour 15 ac wetland	0 (15 * 0.0)	3 (15*0.2)	4.5 (15*0.3)	5.25 (15*0.35)	4.51
Contour 26.8 ac wetland	0 (26.8*0.0)	5.36 (26.8*0.2)	8.04 (26.8*0.3)	9.38 (26.8*0.35)	8.07
Contour 35 ac wetland	0 (35*0.0)	7 (35*0.2)	10.5 (35*0.3)	12.25 (35*0.35)	10.53
Contour 15 ac wetland + plantings & water control	0 (15*0.0)	6 (15*0.4)	9 (15*0.6)	9 (15*0.6)	8.44
Contour 26.8 ac wetland + plantings & water control	0 (26.8*0.0)	12.06 (26.8*0.45)	17.42 (26.8*0.65)	18.22 (26.8*0.68)	16.70
Contour 35 ac wetland + plantings & water control	0 (35*0.0)	14 (35*0.40)	22.75 (35*0.65)	23.8 (35*0.68)	21.63
Contour 15 ac wetland + plantings, water control, & water source	0 (15*0.0)	6.75 (15*0.45)	10.2 (15*0.7)	11.7 (15*0.75)	10.15
Contour 26.8 ac wetland + plantings, water control, & water source	0 (26.8*0.0)	13.4 (26.8*0.5)	25.46 (26.8*0.95)	26.26 (26.8*0.98)	23.84
Contour 35 ac wetland + plantings, water control, & water source	0 (35*0.0)	17.5 (35*0.5)	33.25 (35*0.95)	34.3 (35*0.98)	31.14
Water control for u-shaped wetland	4.8 (12.5*0.38)	6 (12.5*0.48)	9.6 (12.5*0.77)	10.8 (12.5*0.86)	9.58

Reforestation (7 ac), habitat improvement (97.1 ac), native grass buffer (3.8 ac),	63.17	42.15	73.77	89.57	76.55

Once the annualization of habitat units is complete, the final component to be incorporated into the cost effectiveness and incremental analysis is the annualized first costs of the restoration measure, including operation and maintenance costs. Table 12 displays the annualized first costs of all the restoration features in Gateway East.

Table 12
Annualized First Costs for Measures in Gateway East

Measures	Annualize First Costs
Contour 15 ac wetland	$22,445
Contour 26.8 ac wetland	$39,422
Contour 35 ac wetland	$57,803
Contour 15 ac wetland + plants & water control	$27,876
Contour 26.8 ac wetland + plants & water control	$45,350
Contour 35 ac wetland + plants & water control	$64,677
Contour 15 ac wetland + plants, water control & water source	$29,721
Contour 26.8 ac wetland + plants, water control & water source	$47,272
Contour 35 ac wetland + plants, water control & water source	$66,523
Restoration of native grass buffer (3.8 ac)	$1,840
Restoration of native grass/mottes (4.02 ac)	$1,355
Reforestation of 7 ac and habitat improvement of 97.1 ac	$13,213

As was noted earlier in this chapter, an interim incremental analysis was conducted to determine the size of the wetland complex to be implemented in the Gateway East zone. The 26.8-acre wetland complex with water control, plantings, and water source was selected as the plan of choice. In the final incremental analysis, the average annual habitat units gained incrementally as a result of implementation of this wetland cell (23.84 AAHUs) was added to 76.55 AAHUs gained from restoring 3.8 acres of native grass buffer, 4.02 acres of native grass/tree mottes combination, 97.1 acres of habitat improvement, and 7 acres of reforestation and the 9.58 AAHUs gained by adding water control to the u-shaped wetlands. The total number of AAHUs for the Gateway East zone in the overall analysis was, therefore, 109.97 AAHUs.

The total annualized costs input into the overall analysis for the zone included $47, 272 for the wetland complex, $13,213 for the reforestation and habitat improvement, $1,840 for native grass buffer, $1,355 restoration of native grass/mottes plus the annualized costs of the

real estate acquisition, $40,783. Tthe final annualized first costs for the restoration measures proposed for Gateway East totaled $104,463.

The incremental analysis and cost effectiveness calculations within IWRPlan then compare the full scenario of first added to last added measures of the various zones to identify the array of "best buy" plans displayed on Table xx.

TANDY CONSIDERATIONS

Results of the interim analysis of Tandy measures are shown in Table 13, which summarizes the "best buy" combination plan components, the average annual habitat units (AAHUs), the incremental AAHUs, annualized costs, the average annual cost per AAHU, and increment cost per output. The analysis identified 512 possible combinations, 19 considered to be cost effective, and three "best buy" combinations besides the "no action" plan. All the "best buy" combinations for the Tandy zone were included in the final overall analyses

Table 13
Best Buy Plan Combinations for Tandy
Acquisition and Restoration

Plans	AAHU	Incremental AAHUs	Annualized Costs	Incremental Annualized Costs	Average Cost Per AAHU	Incremental Cost Per Output
Acquire Tandy East, invasion control in grasslands & understory, & fencing	71.44	71.44	$184,743	$184,743	$2,585.99	$2,585.99
Acquire Tandy East and West, invasion control in grasslands & understory, fencing, & erosion control	113.56	42.12	$328,031	$143,288	$2,888.61	$3,401.90
Acquire Tandy All, invasion control in grasslands & understory, fencing, erosion control, remove slab & parking & restore	127.00	13.44	$384,066	$56,035	$3,024.14	$4,169.27

EVALUATION OF ALL ALTERNATIVES

PREDICTION OF ENVIRONMENTAL OUTPUTS. Various methods were utilized in the plan formulation phase to help compare and evaluate the existing, future with-, and future without project conditions, including vegetation imagery and HEP. Habitat Suitability Index (HIS) models specific for wildlife and bird species known to utilize the representative habitat types, i.e. grasslands, riparian/bottomland hardwood sites, and wetlands, were used in the HEP analyses. Using HSI values developed during the existing conditions phase of the study for each major habitat type in each zone, habitat units (HUs) were computed by multiplying the HSI values for each of the three important vegetative covers types and open water within each zone by the number of acres of that habitat type within that zone. The final cover type identified by the vegetation classification process was disturbed soils, which were considered to have zero habitat value for these analyses. The habitat units were then averaged and annualized over the life span of a project to derive the average annualized habitat units (AAHUs). In this case, the project life was set for 50 years, based on guidance found in Engineering Regulation (ER) 1105-2-100, Planning and Policy Guidance for Conducting Civil Works Planning Studies. The use of 50 years as the project life does not allow credit for the maximum habitat value of the riparian/bottomland hardwood habitat type since it takes many of the hard mast producing bottomland hardwood trees (e.g. oaks, pecans, etc.) up to 75 years or more to reach their full maturity. Restoration opportunities were evaluated by comparing the baseline AAHUs with projected AAHUs given implementation of a proposed restoration measure or scale within each zone or across the entire project area, as applicable. Projections of the HSI values and the derived future with- and without project AAHUs are based on the professional judgment of resource specialists, including those from USACE, USFWS, and TPWD.

There was no HEP modeling done on the aquatic habitat in the oxbow. At the time of the field surveys, resource specialists, using their professional judgment, decided the value was zero within the oxbow itself, since a majority of the old oxbow channel was either dry or stagnant pools. The majority of the habitat benefits derived for improving the aquatic habitat in the oxbow (reconnecting to the river) were measured in terms of improvements to the adjacent riparian corridor and to the shallow vegetated wetlands that are anticipated to develop along the fringes of the oxbow channel once flow is restored. Even though resource specialists feel that reconnection of the oxbow at both the upstream and downstream end will improve the aquatic habitat in the modified channel and the West Fork downstream of the confluence due to the fact that reconnection will allow migration of aquatic organisms and fish into the oxbow for food, cover, and reproduction purposes and then back out into the main channel, there was no attempt made to quantify or include these benefits into the evaluation of project features. An analysis was conducted however during the plan formulation process to maximize aquatic habitat diversity attributable to the oxbow restoration measures. It was determined that a general water surface elevation of 493 feet msl would provide pools up to six feet in depth a thalweg depth varying from 4- to 6-feet and an average cross sectional average depth of less than four feet. Decreasing the water surface elevation increases the length of channel that would have to be deepened near the upstream diversion to maintain flow. Increasing the elevation produces little additional

wetted perimeter aquatic habitat and produces a greater volume of water with decreased turnover rate thereby decreasing the stream characteristics desired for the oxbow restoration. Table 11 shows the existing conditions habitat units for each vegetation type and open water by project zone along with the future without project average annualized habitat units and acres.

COST EFFECTIVENESS AND INCREMENTAL ANALYSIS. In cost effectiveness and incremental analysis (CE/IA) models, a "no action" measure was developed for each of the separate measures identified. Next average annualized habitat unit gains for each measure and/or scale and their "no action" counterparts were computed over a 50-year period. In addition, annualized costs, including real estate and operations and maintenance costs, were computed for each of the measures. This data was then input into a comparative analysis model. The model used to run cost effectiveness and incremental cost analysis was the IWR-Plan: Decision Support Software, Version 3.3. The final analysis identifies a list of "best buy" plans, which represent the most cost effective plans in terms of costs per habitat units gained. Interim cost effectiveness and incremental analysis were run for 9 alternative combinations for created wetland complexes in both Oxbow Center and in Gateway East. In each case, the study team determined that the medium-sized wetland complexes, 12.3 and 26.8 acres, respectively, along with the addition of quality wetland plants, water control structures that would allow manipulation of water levels to optimize for habitat values during different seasons, and a permanent water supply to be used when necessary to ensure the function and quality of the wetland complex over time, were the "best buy" plans of choice. The AAHUs and annualized costs for each of the selected created wetland complex "best buy" plans for Oxbow Center and Gateway East were added to the AAHUs and annualized costs for the other restoration measures identified for that respective zone and included in final overall analyses.

In addition, interim cost effectiveness and incremental analysis were run for 113 different combinations of land acquisition and restoration measures identified for the Tandy zone. The "best buy" plan combinations identified by the interim analyses for Tandy were shown in Table 12. All three "best buy" combinations were carried forward into the final analysis. The results of the interim and overall cost effectiveness and incremental analyses are included as an addendum to the Environmental Appendix (Appendix E) in this report. This addendum also includes the existing conditions vegetation analysis summary with HSIs and HUs by zone, average annual habitat unit tables for each restoration measure by zone, the annualized cost tables for restoration measures and real estate, copies of the interim CE/IA completed for reforestation and habitat improvement plant densities and materials, the Oxbow Center and Gateway East wetland complexes, respectively, and the Tandy zone, and a copy of the final study wide CE/IA.

FINAL ARRAY OF ALTERNATIVE BEST BUY PLANS. With 8 zones, 11 measures, and several possible scales for some measures (refer to Table 7), IWR-Plan analyzed over 15,728,640 possible combinations. Without-project inputs for the final analysis, by zone, are shown in Table 14. Final results determined that there were 162 cost effective plan combinations and 11 plan combinations considered to be "best buy" alternatives. The best

buy plan results start with the combination plan that provides the greatest number of average annual habitat units (AAHUs) for the least cost and continues to the next plan combination that would increase the number of AAHUs for the next least cost increment until the final plan, which represents the greatest number of AAHUs that can be gained for the last added increment of costs. Table 15 provides a summary of the restoration measures identified in each of these combination plans, along with the AAHUs, incremental AAHUs, annualized costs, incremental annualized costs, and incremental cost per output. Figure 9 is a graphic representation showing the AAHUs and annualized incremental costs for all the best buy plans.

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Table 14. Summary of Acres and Habitat Units by Zone

Project Zone	Forested		Wetland		Grassland		Water		Disturbed	Existing Conditions Totals		Future Without Project Totals	
	Acres	HUs	Acres	HUs	Acres	HUs	Acres	HUs	Acres	Acres	HUs	Acres*	AAHUs
Oxbow North	26.26	15.23	2.22	1.16	68.92	53.07	1.68	0.67	11.85	**110.93**	**70.13**	**104.93**	**23.57**
Oxbow Center	0.22	0.03	0.00	0.00	101.94	78.49	0.00	0.00	22.37	**124.53**	**78.52**	**85.10**	**10.99**
Oxbow South	0.29	0.16	3.08	1.60	29.17	22.46	0.00	0.00	1.47	**34.01**	**24.22**	**28.70**	**4.21**
Gateway Center	9.98	5.29	0.34	0.18	9.22	1.20	0.17	0.06	7.60	**27.31**	**6.73**	**27.31**	**6.73**
Gateway South	15.73	8.33	1.13	0.59	25.33	3.29	0.29	0.12	3.45	**45.93**	**12.33**	**45.93**	**12.33**
Gateway Beach	23.77	9.51	1.90	0.76	86.91	11.30	0.30	0.12	47.12	**160.00**	**21.69**	**138.00**	**18.38**
Gateway Park**	68.60	27.40	0.00	0.00	120.09	15.61	0.00	0.00	68.40	**257.09**	**43.01**	**0**	**0**
Gateway East	97.01	62.09	5.62	2.13	34.94	4.54	0.72	0.29	0.43	**138.72**	**69.05**	**138.72**	**138.72**
Tandy	59.87	24.55	0.80	0.00	90.27	44.23	0.00	0.00	7.71	**158.65**	**68.78**	**158.65**	**48.10**
TOTALS	**301.73**	**152.59**	**15.09**	**6.42**	**566.79**	**234.19**	**3.16**	**1.26**	**170.40**	**1,057.17**	**394.46**	**727.34**	**263.03**

*Adjusted based on constraints as described on pp. 97-103

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Table 15
Incremental Cost of Best Buy Combination Plans – Riverside Oxbow

Plans	AAHUs	Incremental AAHUs	Annualized Costs	Incremental Annualized Costs	Average Cost Per AAHU	Incremental Cost Per Output
Plan 1 - No Action	0	0	$0.00	$0.00	$0.00	$0.00
Plan 2 - **Acquisition and restoration of Oxbow South**	17.02	17.02	$15,617.00	$15,617.00	$917.57	$917.57
Plan 3 - Acquisition and restoration of Oxbow South and **acquisition and restoration of Gateway East**	126.99	109.97	$120,808.00	$104,463.00	$945.59	$949.92
Plan 4 - Acquisition and restoration of Oxbow South; acquisition and restoration of Gateway East; and **acquisition and restoration of Gateway South**	160.10	33.11	$152,448.00	$32,368.00	$952.20	$977.59
Plan 5 - Acquisition and restoration of Oxbow South; acquisition and restoration of Gateway East; **acquisition and restoration of Gateway South**; and **acquisition and restoration of Oxbow Center**	220.66	60.56	$218,453.00	$66,005.00	$990.00	$1,089.91
Plan 6 - Acquisition and restoration of Oxbow South; acquisition and restoration of Gateway East; acquisition and restoration of Gateway South; acquisition and restoration of Oxbow Center; and **acquisition and restoration of Gateway Center**	241.41	20.75	$243,718.00	$25,265.00	$1,009.56	$1,217.59
Plan 7 - Acquisition and restoration of Oxbow South; acquisition and restoration of Gateway East; acquisition and restoration of Gateway South; acquisition and restoration of Oxbow Center; acquisition and restoration of Gateway Center; and **acquisition and restoration of Gateway Beach, including recontouring the wetland complex, adding quality wetland plants, water control, permanent water supply, and removing the old Gateway Entrance road**	333.34	91.93	$359,192.00	$115,474.00	$1,077.55	$1,256.11
Plan 8 - Acquisition and restoration of Oxbow South; acquisition and restoration of Gateway East; acquisition and restoration of Gateway South; acquisition and restoration of Oxbow Center; acquisition and restoration of Gateway Center; acquisition and restoration of Gateway Beach, including recontouring the wetland complex, adding quality wetland plants, water control, permanent water supply, and removing the old Gateway Entrance road; and **acquisition and restoration of Oxbow North, including water flow thru oxbow by removing earthen plug upstream, in-channel weir at confluence, and bridge at Beach along with a series of boulder clusters, planting, a 100-foot-wide native grass buffer strip along wooded riparian corridor, and replacing a water control in the North Pond along with restoration of 12 acres of native grass and tree mottes on the lands around the pond**	421.45	88.11	$505,482.00	$146,290.00	$1,199.39	$1,660.31
Plan 9 - Acquisition and restoration of Oxbow South; acquisition and restoration of Gateway East; acquisition and restoration of Gateway South; acquisition and restoration of Oxbow Center; acquisition and restoration of Gateway Center; acquisition and restoration of Gateway Beach, including recontouring the wetland complex, adding quality wetland plants, water control, permanent water supply, and removing the old Gateway Entrance road; acquisition and restoration of Oxbow North, including water flow thru oxbow by removing earthen plug upstream, in-channel weir at confluence, and bridge at Beach along with a series of boulder clusters, planting, a 100-foot-wide native grass buffer strip along wooded riparian corridor, and replacing a water control in the North Pond along with restoration of 12 acres of native grass and tree mottes on the lands around the pond; and **acquisition of the east portion of Tandy (east of Ben Street) along with restoration of the area by removal of invader species from grasslands and bottomland understory, adding native plantings to understory, and constructing perimeter fencing around Tandy east lands**	495.89	74.44	$697,404.00	$191,922.00	$1,406.37	$2,578.21

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Table 15, continued.

Plans, continued	AAHUs	Incremental AAHUs	Annualized Costs	Incremental Annualized Costs	Average Cost Per AAHU	Incremental Cost Per Output
Plan 10 - Acquisition and restoration of Oxbow South; acquisition and restoration of Gateway East; acquisition and restoration of Gateway South; acquisition and restoration of Oxbow Center; acquisition and restoration of Gateway Center; acquisition and restoration of Gateway Beach, including recontouring the wetland complex, adding quality wetland plants, water control, permanent water supply, and removing the old Gateway Entrance road; acquisition and restoration of Oxbow North, including water flow thru oxbow by removing earthen plug upstream, in-channel weir at confluence, and bridge at Beach along with a series of boulder clusters, planting, a 100-foot-wide native grass buffer strip along wooded riparian corridor, and replacing a water control in the North Pond along with restoration of 12 acres of native grass and tree mottes on the lands around the pond; and **acquisition** of the east **and west portion of Tandy** along with restoration of the area by removal of invader species from grasslands and bottomland understory, adding native plantings to understory, **repair of erosion problems in west portion of Tandy and replanting with native grasses, and construct perimeter fencing on Tandy east and west lands**	535.01	39.12	$846,566.00	$149,162.00	$1,582.34	$3,812.94
Plan 11 - Acquisition and restoration of Oxbow South; acquisition and restoration of Gateway East; acquisition and restoration of Gateway South; acquisition and restoration of Oxbow Center; acquisition and restoration of Gateway Center; acquisition and restoration of Gateway Beach, including recontouring the wetland complex, adding quality wetland plants, water control, permanent water supply, and removing the old Gateway Entrance road; acquisition and restoration of Oxbow North, including water flow thru oxbow by removing earthen plug upstream, in-channel weir at confluence, and bridge at Beach along with a series of boulder clusters, planting, a 100-foot-wide native grass buffer strip along wooded riparian corridor, and replacing a water control in the North Pond along with restoration of 12 acres of native grass and tree mottes on the lands around the pond; and **acquisition of all of Tandy** along with restoration of the area by removal of invader species from grasslands and bottomland understory, adding native plantings to understory, repair of erosion problems in west portion of Tandy and replanting with native grasses, **construction of perimeter fencing on all of Tandy lands, and removal of slab and parking lot on commercial properties, repair of slope erosion, and replanting with natives**	548.45	13.44	$904,710.00	$58,144.00	$1,649.58	$4,326.19

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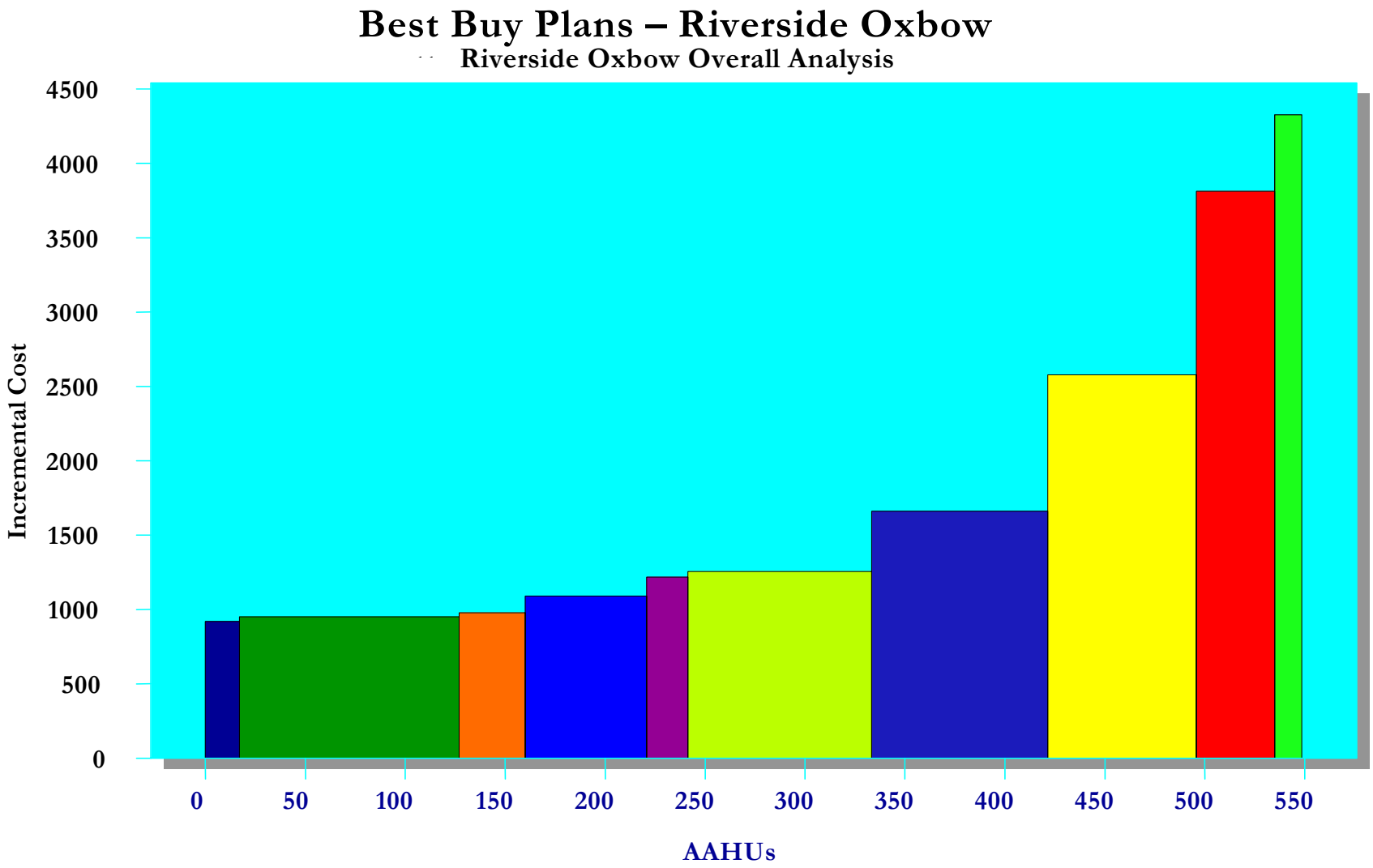
Figure 9
Best Buy Combination Plans for Riverside Oxbow Restoration Measures and/or Scales



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Based on the incremental analysis, the study team determined that Plan 8, represented by the light blue bar in Figure 9, would be the combination plan recommended as the National Ecosystem Restoration Plan. The plan provides for the acquisition and restoration of a majority of the lands within the study area, except for lands eliminated from consideration for restoration efforts because of constraints or potentially incompatible future usage based on preliminary plan formulation as described earlier in this Plan Formulation chapter, and properties of the Tandy zone, which were removed from further consideration per policy guidance from USACE Headquarters. Table 16 summarizes the acres and habitat units for existing, future without- and future with project conditions by project zones based on implementation of Plan 8 as the NER plan. The changes in acreages and habitat units from Table 2 in the Existing Conditions chapter represent changes made during the plan formulation process.

Table 16
EXISTING A CRES AND HABITAT UNITS FOR
EXISTING, FUTURE WITH, AND WITHOUT PROJECT CONDITIONS

	Acres	HU s	Future Without Restoration (50 yr) AAHUs	Future With Restoration (50 yr) AAHUs
Oxbow North	104.90	67.38	23.57	88.11
Oxbow Central	85.1	54.4	10.99	60.56
Oxbow South	28.71	20.90	4.21	17.02
Gateway Central	27.30	6.73	3.93	20.75
Gateway South	45.93	12.33	3.57	33.11
Gateway Beach	138.00	18.38	10.09	91.93
Gateway East	138.72	69.05	63.48	109.97
TOTALS	**568.66**	**249.17**	**119.84**	**421.45**

IMPORTANCE OF PROJECT OUTPUTS. Bottomland and riparian woodland and wetland habitats are recognized as having national importance, due to their previous and continuing susceptibility to loss and because they are considered to have significant value for certain fish and wildlife species of national importance, such as migratory waterfowl and neotropical birds species that are protected by national and international treaties. One hundred and eighty nine species of trees and shrubs, 42 species of woody vines, 75 species of grasses, and 802 species of herbaceous plants occur in Texas' bottomlands. They are known to support 116 species of fish, 31 species of amphibians, 54 species of reptiles, 273 bird species and 45 species of mammals. At least 74 species of threatened and endangered animals depend directly on bottomland hardwood systems and over 50 percent of neotropical songbirds not listed as endangered or threatened are associated with these systems. Besides contributing to the biodiversity of Texas, and providing critical wildlife and bird habitat, bottomland hardwood systems with associated wetlands 1) serve as catchment and water retention areas in times of flooding; 2) help control erosion; 3) contribute to the nutrient cycle, and 4) play a vital role in maintaining water quality by serving as a depository for sediments, wastes and

pollutants from runoff. Despite these important functions, bottomland hardwoods ecosystems are one to the most endangered ecosystems in the United States.

As noted in Table 16 above, the number of AAHUs in the project area under future without project conditions is 119.84 AAHUs, while the number for future with project conditions is 421.45 AAHUs. This means that under project conditions there will be a gain of 301.61 AAHUs over future without project conditions. Therefore, in addition to being consistent with State and Federal government initiatives to conserve and increase declining wetland acreage and the North American Waterfowl Management Plan with its goal of preserving and increasing North America's waterfowl population, implementation of the NER plan would increase the habitat value of the study area over 250 percent above the without project conditions. Specifically, the NER plan would restore or create approximately 56.5 acres of wetlands, improve the quality of the habitat on 179.7 acres of bottomland hardwood and mixed deciduous forest stands, reforest 66.9 acres of open space to bottomland hardwoods, restore 206.9 acres of native floodplain grass prairie, restore 45.6 acres of native grassland buffer and create 13.1 acres of open water, in addition to restoring flow back through the oxbow. Subsequently the remaining acres of existing habitat within the study area become more valuable by reducing the fragmented nature of the existing habitat and restoring a contiguous corridor for migration of avian and wildlife species through the area. The NER plan directly addresses the loss and scarcity of resources as described above as well as complements various local, regional, state and federal plans for restoring and preserving resources. In addition, the plan fulfills the objectives that were identified by the study team during the plan formulation process.

RIVERSIDE OXBOW
FORT WORTH, TEXAS

CHAPTER 5
RECOMMENDED PLAN

This chapter provides further details on the Recommended Plan, as determined in the preceding chapters of this report. Preliminary costs, at April 2003 prices levels, are presented, as well as federal and non-federal cost apportionment responsibilities.

NATIONAL ECOSYSTEM RESTORATION PLAN

The NER plan will restore the biological integrity of the wetland and bottomland hardwood communities through a combination of measures directed at either specific habitat types or specific problems within the existing ecosystem. Collectively, these restoration measures will help restore the ecological integrity, function, and dynamic processes of the floodplain and adjacent uplands to a less degraded, more natural condition. In identifying the NER plan, the study team evaluated the array of plans proven to be cost effective and incrementally justified as identified by the cost effectiveness and incremental analysis. The next step was to further evaluate the individual plan elements and determine whether the additional habitat unit gains warranted the additional incremental costs.

The major restoration elements of the NER plan are shown in insert. Since the proposed overall restoration plan is relatively complex, the description of specific project features has been broken down into the previously identified zones. The following paragraphs describe the restoration measures for each zone, including the number of acres for each restoration planting type in each zone for the NER plan. As noted from Chapter 4, reforestation includes planting 40 one-inch caliper containerized trees, 20 one-gallon containerized shrubs, and 150 seedlings per acre and habitat improvement measures include planting 5 one-inch caliper containerized trees, 5 one-gallon containerized shrubs and forest management techniques (selective thinning, nesting boxes, etc.) per acre.

Oxbow North. Following is a list of the various restoration activities or features included in the recommended plan for the Oxbow North zone:

- Acquisition of 104. 93 acres of property
- Widening the riparian corridor to 330 feet (approximately 100 meters) by reforestation of 20 acres of grass and disturbed lands
- Habitat improvement of 20.33 acres of existing wood stands
- Replacement of the spillway in the pond north with a water control structure
- Establishing a 100-foot wide native grass buffer (36.4 acres)

- Conversion of existing grasslands with a native grassland and tree motte combination (12 acres total – 10.8 acres of grasslands with 1.2 acres of reforestation)
- Reconnect the upstream end of the oxbow to the river by removal of the earthen plug along with a maintenance bridge to span the opening (see insert, which depict side by side cross sections of the oxbow at the upstream end with the plug removed and further downstream)
- Replace the culvert at Beach Street with a full span bridge
- Construction of an in-channel weir just upstream of the downstream confluence of the oxbow with the West Fork (see insert, which displays cross sections of the modified and oxbow channels just above the in-channel weir and the low water dam below Beach)
- Improvement of in-stream aquatic habitat by adding a series of 3 boulder cluster complexes

Figure 15 displays side-by-side cross sections of the oxbow under anticipated future with project conditions and the natural channel of the West Fork downstream of the confluence adjacent to the Gateway East zone. This section of the West Fork has never been physically modified, but has been indirectly impacted by a number of flood control projects and reservoirs located upstream, which will be the same for the oxbow once it is reconnected to the river. It is anticipated that once the oxbow is reconnected to flows at both the upstream and downstream ends and is open to flush flows from flooding events, it will return to a more natural, less degraded condition and once again begin to reflect the more natural floodplain of the West Fork.

Oxbow Center. Following is a list of the various restoration activities or features included in the recommended plan for the Oxbow Center zone:

- Acquisition of 85.1 acres of property
- Creation of a 12.3-acre wetland complex with the addition of emergent wetland plantings (7.2 acres), a water control structure, and a permanent pump station
- Conversion of existing grasslands with a native grassland and tree motte combination (71.6 acres total – 64.4 acres of grasslands with 7.2 acres of reforestation)

Oxbow South. Following is a list of the various restoration activities or features included in the recommended plan for the Oxbow South zone:

- Acquisition of 28.71 acres of property
- Reforestation of 2 acres of bottomland hardwood corridor along IH-30 and Sycamore Creek
- Habitat improvement of 7.8 acres of existing wood stands
- Establishing 0.9 acres of native grass buffer
- Conversion of existing grasslands or disturbed areas with a native grassland and tree motte combination 14.9 acres total – 13.4 acres of grasslands with 1.5 acres of reforestation)

Gateway Center. Following is a list of the various restoration activities or features included in the recommended plan for the Gateway Center zone:

- Acquisition of 27.3 acres of property
- Reforestation of 1.5 acres of bottomland hardwood riparian corridor along the south side of the oxbow from Beach Street to the oxbow's confluence with the West Fork and along the top of the bank on the north side of the improved channel
- Habitat improvement of 9.7 acres of existing wood stands
- Establishing 3.2 acres of native grass buffer
- Conversion of existing grasslands and disturbed areas with a native grassland and tree motte combination 12.9 acres total – 11.6 acres of grasslands with 1.3 acres of reforestation

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Figure 11 - NER Plan

Figure 12

Figure 13

Figure 14

Figure 15

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Gateway South. Following is a list of the various restoration activities or features included in the recommended plan for the Gateway South zone:

- Acquisition of 45.93 acres of property
- Reforestation of gaps in the existing riparian corridor along the oxbow and establishment of a bottomland hardwood corridor along IH-30 from Beach Street to the eastern boundary of the zone (13.3 acres)
- Habitat improvement of 15.7 acres of existing wood stands
- Establishing 1.3 acres of native grass buffer
- Conversion of existing grasslands with a native grassland and tree motte combination (15.6 acres total – 14.0 acres of grasslands with 1.6 acres of reforestation).

Gateway Beach. Following is a list of the various restoration activities or features included in the recommended plan for the Gateway Beach zone:

- Acquisition of 138.0 acres of property
- Habitat improvement of existing wetlands by recontouring slopes, planting emergent and forested wetland vegetation (29 acres) along with selective thinning, as needed, adding a water control structure and a permanent water supply, and removing the existing park entrance road to reestablishing the hydraulic connection between the wetland ponds and the oxbow
- Conversion of existing grasslands with a native grassland and tree motte combination (99 acres total – 89.1 acres of grasslands with 9.9 acres of reforestation)

Gateway East. Following is a list of the various restoration activities or features included in the recommended plan for the Gateway East zone:

- Acquisition of 138.72 acres of property
- Reforestation of gaps and narrow areas in the existing riparian corridor along the West Fork (7 acres)
- Habitat improvement of 97.1 acres of existing wood stands
- Creation of a 26.8-acre wetland complex, adding a water control structure, planting 10 acres of emergent wetland plants and 4 acres of moist soil plants, and adding a permanent water supply along with construction of a water control to u-shaped wetlands (old oxbow remnant)
- Establishing 3.8 acres of native grass buffer to protect riparian habitat along the West Fork
- Conversion of existing grasslands with a native grassland and tree motte combination (4.02 acres total – 3.62 acres of grasslands with 0.4 acres of reforestation)

OPERATIONS AND MAINTENANCE (O&M) ACCESS. The recommended plan also includes operations and maintenance access. This access consists of two oxbow channel access points; one located near the upstream end of the oxbow and the second located just upstream of Beach Street. The remaining O&M access consists of approximately 10,800 linear feet of cleared and stabilized dirt overlaid with a crushed aggregate surface with a width of eight feet. This access is located along the oxbow in the Oxbow North zone, around the north pond in Oxbow North, and adjacent to the wetland complex in Oxbow Center. In addition, a portion of the costs for the 8,967 linear feet of 10-foot wide concrete

trail, which runs along the banks of the modified channel and along the west side of Beach Street to the north, have been apportioned to O&M access. These costs are associated with increased pavement thickness to accommodate usage by operations and maintenance vehicles during wet conditions. These access features are the minimum required to accomplish the operations and maintenance of the recommended plan features. Other components of the proposed restoration in other zones can be accessed via existing roads or trails of others and are not included as part of the recommended plan operation and maintenance access.

RECREATION. As part of the overall Clear and West Fork Interim Feasibility Study, a major effort was initiated to look at the existing recreation facilities, solicit input from local citizens and groups as to their interests in, and concerns for, the Trinity River and its tributaries and to identify future recreation needs. A section of the overall recreation master plan, called the West Fork East, encompasses the Riverside Oxbow study area. Public meetings for this segment identified an array of recreation needs and interests in the study area. They include: 1) additional trails along the Trinity River corridor and optimum linkages with existing or planned trails outside the project; 2) safe neighborhood access to the "Trinity Trails" system; 3) increased water related recreation, including canoeing and kayaking, fishing, etc.; and finally, 5) restoration and preservation of the natural resources that make the river unique.

With input from these various entities and following Corps of Engineer policy and guidance, the Riverside Oxbow study team identified recreation features to be incorporated into the NER plan. The recreation features would not detract from the ecosystem restoration objectives since there are generally being located along the perimeter, in areas that have already been disturbed and, where possible, utilize or share access designated for operations and maintenance. The recommended plan includes some recreational features that are not required solely for project construction or operations and maintenance. These features are described as strictly recreational and are cost shared at 50/50 percent between the Government and the non-Federal sponsor, per Corps guidance. Recreation access includes approximately 7,519 linear feet of equestrian trail that will be 10 foot wide, stabilized dirt covered with wood mulch in Gateway Beach; 8,967 linear feet of pedestrian trail that is 10-foot wide reinforced concrete along the improved channel in the Oxbow Center and Gateway Center (where it connects to an existing trail system) and along the west side of Beach Street from the improved channel north to the limits of the project area; and 1,396 linear feet of 8-foot wide crushed aggregate trail in the Gateway South. In addition, recreation access features include recreation access points with associated parking. One is located off of Riverside Drive just north of the river channel and west of the oxbow and would provide access to the project area near the upstream end of the oxbow channel. The access road at this location would be 710 linear feet long with an associated parking lot of 5040 square feet. The second access point is located west of Beach Street, south of the oxbow channel and would provide access to the project area upstream of Beach Street. The access road here is 616 linear feet in length with an associated parking of 5040 square feet. In addition, there are restroom facilities at each of the parking access points.

The Tarrant Regional Water District, the city of Fort Worth, and Streams and Valleys strongly support the incorporation of the above recreational purposes and features into the recommended plan. These features are compatible with the city's Gateway Park Master Plan and the Fort Worth portion of the Trinity River Visions Master Plan. Both plans are also compatible with the recommended ecosystem restoration project and provide links to both

the east and the west for trails, either existing or proposed, as part the regional Trinity Trails Plan.

The formulation of recreational features was conducted within the following framework:

- are totally ancillary, i.e. project was not formulated solely for recreation
- do not add to the project cost
- take advantage of the project's recreation potential
- are not vendible
- would not exist without the project
- are within the maximum 10% federal cost participation limit

Economic justification is based on an evaluation of competing facilities, existing and expected future use with and without the recommended plan, and unfulfilled demand. According to the Texas Parks and Wildlife Department, Texas Outdoor Recreation Plan (TORP), which identifies population, usage, and demand trends with the region, including the study area, the demand for recreation facilities, such as trails, is steadily increasing. Applying the appropriate participation rates the population of potential users, the access will be used to capacity from the time it becomes available to the public through the period of analysis.

Current standards indicate that the concrete (8,967-feet in length, 10-foot wide) and the crushed aggregate (total of 1,396-feet in length, 8-foot wide) pedestrian trails can accommodate 57,700 visitors per mile per year and 6,999 visitors per year per mile of trail for the equestrian trail. Total capacity usage for the concrete pedestrian trail is, therefore, (57,700/5,280) times 8,967 equals about 98,000 visitors per year. Total capacity for the crushed aggregate trail is (57,000/5,280) times 1,396 equals about 15,300 visitors per year. Total capacity usage for the equestrian trail is (6,999/5,280) times 7,519 equals 10,000 visitor days per year. Total visitor days per year equal 123,300.

Point values are assigned based on selective criteria applicable to the proposed trail. The criteria and assigned points are as follows:

• Recreational experience	–	16 points
• Availability of opportunity	-	3 points
• Carrying capacity	–	8 points
• Accessibility	–	18 points
• Environmental quality -		10 points
		55 points

The current unit day value (general recreation) for Fiscal Year 2003 is $6.53 for 55 points. Applying this value to 123,300 visitor-days per year results in a benefit of approximately $805,100 per year. Any project features that serves a purely recreational purpose will be assigned solely to recreation. Project features required for project construction, operations, or maintenance will have their costs apportioned to ecosystem restoration. Table 17 displays the costs associated with the recreational features and a summary of their expected annual costs and benefits.

Table 17
Economic Justification of Recreational Feature Costs
(Based on October 2002 Price Levels, 5.875 interest rate)

Recreation First Costs[1]	Annual Cost	Annual Benefit	Benefit-Cost Ratio
$997,000	$79,000	$805,100	10.0

*From MCACES.

LOCALLY PREFERRED PLAN (LLP)

At the request of the local sponsor, and with input from the various other entities, the study team was asked to evaluate an alternative to the NER plan that would be a buy up from the NER plan, incorporating additional recreation and restoration features of interest to the local citizens. The local sponsor understands that these additional features are outside the scope of USACE policy and guidance for potential cost sharing and realizes that these added features would have to be funded solely from non-federal funds.

The additional features included within this locally preferred alternative include relocation of the entrance to Gateway Park to include a new access road and bridge over the oxbow channel in the Gateway Center zone and three observation decks. The local sponsor decided to include acquisition of a 112.04-acre portion of the Tandy zone (all the lands east of Ben Street), and restore the native prairie grasslands by removing eastern red cedar, mesquite, and other woody invasive species; clear the invading exotic species from bottomland hardwood understory and replant with native understory vegetation, and construct perimeter fencing to limit access from off road vehicle use and protect resources in the zone. In addition, there would be a parking lot added and approximately 7,700 linear feet of crushed aggregate trail for pedestrian usage. At the request of the local sponsor in a letter dated April 10, 2003, this plan is the "Locally Preferred Plan." Figure 16 provides a display of the LPP.

Without the recreation features discussed above, those in Tandy and the new Gateway Park entrance road and bridge, along with the observation decks, this LPP replicates the "best buy" combination Plan 9 as identified in Table 15 in Chapter 4. In fact, Plan 9 was the ranked next highest to the NER plan in incremental cost per output. The restoration proposed for the LPP will increase average annual habitat unit gains in the project area by 74.44 over the NER plan. Working in conjunction with the local sponsor, this LPP has been selected as the recommended plan for the Riverside Oxbow, Trinity River, Fort Worth, Texas project.

Figure 16

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ENVIRONMENTAL EFFECTS OF THE RECOMMENDED PLAN

General description. The basis of the plan formulation planning objectives for the Riverside Oxbow study was to restore ecosystem values through modification of existing resource features in the area. Following design of the restoration alternatives, minor recreational components that do not reduce restoration benefits were evaluated and added into the National Ecosystem Restoration plan. If the ecosystem restoration project is not built it is expected that a less environmentally sensitive use of the area would occur. More mowing, less management of invading non-native trees and shrubs in the riparian zone and the continued fragmentation of riparian resources caused by the Beach Street bridge would reduce fish and wildlife resources of the area during the study period. The project sponsor has developed a locally preferred plan that is based upon the NER but would also include additional restoration located within the Tandy Hills area south of IH-30. Increasing the size of the entire ecosystem restoration area would be expected to increase habitat benefits for the riparian ecosystem and provide an example of upland management that could prompt land owners, public and private, to consider removal of non-native vegetation from open areas upstream of the study area. Should that happen, resources of the Upper Trinity River basin would be further improved. It is also anticipated that the LPP would provide some, but currently non-quantifiable reduction in maintenance costs in the NER area due to anticipated future reduction of non-native invading plant species and reduced sedimentation within the aquatic components of the project.

Land Use. The study area includes undeveloped private lands and publicly owned properties. There currently is low demand for business development along the private lands and therefore implementation of the restoration plan would have minimal negative impact on future land use. Land use on the ecosystem restoration areas would remain essentially the same as currently conducted however; placing the entire area in public ownership and management for restoration and improvement of ecosystem values would provide a positive environmental benefit.

Hydrology and Hydraulics. Ecosystem restoration activities as proposed in the NER would increase wooded vegetation thereby slowing floodwaters and affecting valley storage in the study area. The NER plan incorporates hydraulic mitigation consisting of excavation of floodplain material near the south shoreline of the existing channelized segment of the West Fork. With the mitigation, the plan meets the criteria of the Environmental Impact Statement and Record of Decision (ROD) in 1988. Meeting these criteria minimize the cumulative hydraulic and hydrologic impacts of the project to the Upper Trinity River Basin. No significant impacts to hydrology or hydraulics would occur from implementation of the project.

Water Quality

The recommended plan involves increasing the amount of existing forest in the study area through the conversion of grass and shrub lands to forest. It also calls for the demolition and removal of the Beach Street bridge over the oxbow. Initially, construction and planting of vegetation could temporarily result in a slight increase in the suspended sediment load in the study area from stormwater runoff across newly vegetated areas. In addition, activities associated with the construction of the linear hiking trail and pedestrian bridge crossings

could increase the sediment load on a temporary basis. The reconstructed bridge would span the stream channel and is not expected to cause any lasting adverse impacts on the water quality of the study area.

Numerous studies have addressed the buffering effects of vegetation. Iowa State University research shows that buffer strips are capable of removing more than 70 percent of the sediment from runoff flowing from slopes with grades as high as 12 percent. By slowing runoff, buffers give water time enough to soak into the soil, thereby reducing runoff volume. The vegetation then acts as a filter, removing sediments, heavy metals and hydrocarbons. Over time, the features of the recommended plan would be expected to be self-sustaining with respect to achieved improvements in water quality.

Implementation of the plan would have short-term negative impacts because of the demolition, reconstruction and vegetation management activities. The long-term effects of the buffering and filtering of vegetation as a result of restoration activities would offset any short-term negative impacts. There would be no significant adverse impacts to the water quality of the West Fork of the Trinity River from implementation of the plan, except on a temporary basis, and the restoration activities would positively impact water quality in the long-term.

Air Quality. One parameter to be potentially effected by the future conditions with the recommended project plan would be air quality. Implementation of the recommended plan entails increasing existing forest acreage by converting grasslands to forest.

The proposed increase to the size of the forest in the project area would add additional air pollutant removal capabilities to the existing forest and improve the quality of air. A computer model developed by the United States Department of Agriculture's (Urban Forest Effects [UFORE]) has been used to describe the effects which trees have on the removal of the five gaseous criteria pollutants in the Johnson Creek and Dallas Floodway Extension study areas. Although this modeling effort was not conducted for the Riverside Oxbow, the past research has established that healthy riparian forest and grasslands have the capability to remove air pollutants.

No significant adverse impacts to air quality would occur from implementation of the LPP or NER Plan, rather, either should help to improve air quality in the area.

Terrestrial Resources.

Vegetation. Since the project, as proposed, is an ecosystem restoration plan including acquisition, preservation and management bottomland hardwoods and grass and shrubs lands for ecosystem restoration and passive recreational features such as a linear hiking trail and parking, picnic and facilities development, the overall environmental effects are expected to be positive.

The recommended plan would utilize the qualities of the existing topography and soils to develop additional forested habitat. Reforestation would be accomplished through forestry techniques for the trees, shrubs and seedlings, which would cause minimal disturbance to the soil. Disturbance to the existing habitat from the construction of recreation features would be kept to the minimal amount and size of disturbance possible. Safeguards to reduce soil erosion would be implemented as need during the construction of the recreational features

and during the demolition and removal of structures in the evacuation/buyout area. The disturbed soils along the construction sites and in the buyout areas would be stabilized with native vegetation.

No significant adverse impacts to soils would occur from implementation of the plan and overall, would significantly increase the quality, size and continuity of the riparian bottomland forest in the project area, even when taking into consideration the provision of the recreational elements.

Wildlife Resources. The Riverside Oxbow lies within a highly developed metropolitan area that has been highly impacted by human activities. Generally the wildlife species found there are typical of those found in highly urbanized areas. The numbers and species of wildlife found in the area can be directly attributed to the habitat available for nesting, foraging, shelter, reproduction and rearing of offspring. Any improvements to the quality of the existing habitat or increases in the quantity of habitat would have positive effects on wildlife numbers and species.

Demolition and construction activities associated with the reconstruction of the Beach Street bridge, construction of wetlands and restoration of riparian forests within the project area and minor recreational trail access and subsequent activities associated with maintenance of ecosystem restoration and recreational features are expected to have insignificant short term negative impact on existing wildlife species. The acquisition of lands for ecosystem restoration and the increases in habitat quality and quantity are expected to positively impact the wildlife resources, especially neotropical songbirds, small mammals, fish that require local seasonal migration, amphibians and reptiles. Although not considered in the benefits at this time, the bridge replacement design will consider the potential for adding roosting habitat for bats and swallows. The grassland/wetland/riparian complex that would result from the ecosystem restoration would provide an abundance of food, primarily small hovering insects that would be ideal prey. Currently little to no roosting habit occurs for bats and swallows in the study area.

No significant adverse impacts to wildlife resources would occur from implementation of the plan and it would significantly increase the quality and quantity of habitat in the project area. No environmental mitigation is needed for any aspect of the NER or LPP.

Aquatic Resources. Demolition and removal of the Beach Street bridge culvert coupled with restoration of continuous flow through the oxbow vegetation would significantly improve the quality of aquatic habitat in the Riverside Oxbow and contribute to improvements within the West Fork downstream of the confluence of the oxbow. The oxbow would also provide a beneficial low velocity hiding area for fisheries resources during West Fork during flooding events.

Development of forested areas around and over the stream would provide shade to help maintain water temperatures within optimum ranges for growth and development of aquatic organisms. More trees and vegetation within the riparian zone plus the native grass buffer along the wooded riparian area of the oxbow would improve the ability of corridor to provide buffering against environmental pollutants in stormwater runoff and balance the input of organic nutrients to the oxbow and ultimately the West Fork. Permanent aquatic resources of the Riverside Oxbow, aquatic resources of the ponded areas, and deeper pools of the proposed emergent wetlands would provide refugia during drought and intentional

wetland management activities and would support a high diversity and resilient aquatic biota. Aquatic biota such as largemouth and spotted bass, white bass, bluegill, crappie, channel catfish, shiners, darters, zooplankton, aquatic insects, mussels, and various species of snails could ultimately inhabit the study area.

Implementation of the plan might also cause minor short-term negative impacts to the aquatic resources in the study area during the demolition and construction phase of the project until channel conditions stabilize. However, in the long run, because of the buffering and shading effects of vegetation along the riparian zone, the long-term impacts are expected to be positive.

No significant adverse impacts to aquatic resources would occur from implementation of the plan and over time the project would result in significantly increased quality of aquatic habitat in the project area

Wetlands. Within the project area, 15.1 acres of vegetated emergent wetlands were identified. The wetlands identified are in remnant depressions caused by disturbances related to implementation of the previous West Fork channelization within the drying beds of the abandoned wastewater treatment plant in the existing Gateway Park. Some additional wetland vegetation was observed along the banks of the existing West Fork of the Trinity River channel. A gravel pit and associated wetlands complex in the Gateway Beach zone are currently the most active from a wildlife utilization perspective. The project as proposed would modify the drying beds, enlarge a small ephemeral wetland in the Oxbow Central area provide hydraulic stabilization at an existing pond in Oxbow North zone and provide grading and dependable water supply for wetlands in the Gateway Beach zone. Modifications at these sites would improve the quality of the existing wetlands through enlargement and through operation and management. Following project implementation there would be a complex of wetlands, including deeper water refugia and riparian fringe. Wetlands would comprise 56.5 acres of the 69.6- acre wetland complex.

General Aesthetics.

Noise. Sound levels within the Riverside Oxbow study area are typical of those found in urban neighborhoods within the Dallas-Fort Worth Metroplex. Noise levels in the area would be expected to increase for a short time while demolition and construction activities are ongoing as a result of the added noise of heavy equipment and workers in the area. However, over the long run increasing the amount of forest in the area along the Riverside Oxbow corridor should buffer the sounds of traffic and general noise to and from the area.

Light. The only lighting proposed for the recommended plan would be located in the parking lots at the access areas. The lighting would be to provide security only and would be of a low light type mounted high with cut-offs to prevent stray light from impacting adjacent residential areas. Therefore, there would be no significant adverse impacts caused by lighting requirements for the proposed project with either plan. Projects proposed by others might cause additional lighting impacts, however, lighting affecting the area would be required to be directional thereby minimizing any affects to ecosystem restoration benefits.

Traffic Patterns. There would be temporary impacts to traffic patterns

caused by the reconstruction of Beach Street Bridge. There would be no significant adverse impacts on local traffic patterns with implementation of other measures of either the LPP or NER plans. Motorized vehicles would be restricted to the streets leading to the parking lots and access points. Efforts to notify the public of the temporary disruption of traffic flow across this area and to alert the public to alternative travel means will be conducted to minimize public inconvenience.

Sustainability. Ecosystem restoration features proposed would facilitate long-term sustainability of resources with minimal exterior inputs. Some additional maintenance would be required during establishment of vegetation and riddance of nuisance invaders, however, the overall plan would ultimately result in a mature riparian ecosystem that is stable needing less maintenance that would be required to maintain other land uses. The emergent wetlands proposed would require a higher rate of maintenance due to the need to provide an artificial watering regime to optimize habitat benefits. Due to the overall management of the Upper Trinity River system that has produced tremendous economic benefits to the public by reducing flood damages, no other means other than pumping appear feasible for restoring the emergent wetlands. The incremental analysis conducted during this study support the wetland restoration, due the high quality and diversity these features would provide.

STATUS OF ENVIRONMENTAL COMPLIANCE

Section 404 - Clean Water Act. The proposed project has been reviewed in accordance with Section 404 of the Clean Water Act. The recommended plan is primarily an ecosystem restoration plan with associated minor recreational trail development. The proposed project meets the terms and conditions of nationwide permit 27 for Stream and Wetland Restoration Activities. The State of Texas has reviewed and provided water quality certification for nationwide permit 27, and no further evaluation of Section 404 of the Clean Water Act is necessary.

Section 10 of Rivers and Harbors Act. Navigability extends up the West Fork of the Trinity River to Riverside Drive. Therefore the project has been reviewed for compliance with Section 10. Stream flow diversion from the impounded section of the channelized West Fork would be diverted for stream restoration within Riverside Oxbow. During low flow events the diversion would be approximately 2 to 3 cubic feet per second or approximately 25% of the flow in the West Fork during those events. However, because of the existing dam structure below Beach Street on the channelized segment, no modification to depths or navigability would result. The proposed restoration activities would not affect navigability and therefore the project is in compliance with Section 10.

Executive Order 11988 - Flood Plain Management. In addition to Section 404, Executive Order 11988, Floodplain Management, was considered during the development of the proposed project. There are no practical alternatives to achieve the project purposes of ecosystem restoration and recreation trail development without placing fill within the floodplain. Material removed from the project area requiring disposal, as part of the plan, would be placed in approved landfills for the types of materials involved. The proposed fill actions would not result in adverse environmental impacts and further, floodplain fill for recreational trail and ecosystem restoration would not directly or indirectly induce additional

development in the floodplain and would therefore be in compliance with Executive Order 11988.

Executive Order 11990 - Protection of Wetlands. Executive Order 11990, Protection of Wetlands was considered during the development of the proposed project. The proposed project would increase the size and quality of wetlands in the area without adversely impact existing wetland areas so the project is in compliance with Executive Order 11990.

Construction Storm Water. The Texas Pollutant Discharge Elimination System (TPDES) program as of March 5 2,003 implements the National Pollutant Discharge Elimination System. The TPDES Construction General Permit is administered by TCEQ for two different phases of construction based upon size of the disturbance. The project as proposed will likely cause disturbance to more than one acre of soils, and prior to commencement of construction a stormwater pollution prevention plan will be developed a Notice of Intent will be submitted to the TCEQ, followed by submittal of a Notice of Termination once the construction site has reached final stabilization.

Threatened and Endangered Species. The U.S. Fish and Wildlife Service has reviewed the proposed project and provided concurrence that the proposed the project is not likely to adversely affect threatened or endangered species. Prior to construction a review would be conducted to determine if additional new species or impact information become available sufficient to warrant further consultation.

Environmental Justice. Implementation of the proposed project would not cause any adverse impacts to the economically depressed or minority areas adjacent to the study area. The project would improve existing environmental conditions that could enhance the values of adjacent lands. Other than the temporary impacts attributable to impaired traffic flow associated with the Beach Street bridge removal, no impacts to residents adjacent to the area should occur. The project is compliance with the Executive Order on Environmental Justice.

Cultural Resources. Cultural resources compliance issues for the Riverside Oxbow study have been addressed through consultation with the Texas State Historic Preservation Office (SHPO) in accordance with Section 106 of the National Historic Preservation Act. On site investigations (Cultural Resources Assessment of Riverside Oxbow Environmental Restoration, Fort Worth, Tarrant County, Texas) resulted in the identification of historic archeological properties that could be impacted by excavation of the proposed return channel from the Oxbow Central Zone wetlands. As a result of that finding, the channel's alignment was modified to avoid those historic properties. The SHPO has tentatively concurred with the Corps' proposal to survey the modified alignment prior to construction so that final adjustments can be made as required to avoid any undiscovered historic properties. Correspondence related to the Cultural Resources consultation is located within the correspondence section of the Feasibility Report.

Cumulative Impacts. The Corps of Engineers has conducted a Programmatic Environmental Impact assessment (PEIS, 2000) that addresses cumulative impacts of Corps of Engineers proposed activities associated with the Upper Trinity River Basin. That document identified concern related to the continued loss of riparian or bottomland forests and wetlands within the study area. The NER and the LPP would not result in adverse

cumulative impacts to the resources identified as important in the PEIS. The project would provide improvement to those resources. The hydraulic and hydrologic impacts would be mitigated as identified in the plan and therefore would also be in compliance with criteria identified during a previous Programmatic EIS for the Corps Regulatory program. Therefore the NER and LPP would not cause negative cumulative impacts to resources of significance as identified during this and past studies.

ECONOMIC ANALYSIS

First Costs. The first costs included lands and damages, utility relocation, dams, channels and canals, fish and wildlife facilities, roads and bridges, planning, engineering, and design costs, and project management. Table 18 displays the summary of the estimated first costs for the NER and LPP/Recommended plans. These costs are based on detailed design and final cost estimating as incorporated in MCACES documents (see Appendix J, Cost Estimating). Real estate costs are based on the Real Estate Plan that was completed in October 2002 (Appendix E).

Table 18
Summary of First Costs
NER and LPP Plans
(October 2002 price level)

Work Item	NER Plan	Locally Preferred Plan
Lands and Damages [1]	$3,306,000	$6,178,000
Utility Relocations	$788,000	$788,000
Dams	$144,000	$144,000
Channels and Canals	$589,000	$589,000
Fish and Wildlife Facilities	$5,188,000	$5,378,000
Roads and Bridges [2]	$1,382,000	$5,218,000
Recreation Facilities [3]	$1,224,000	$1,356,000
Planning, Engineering, and Design [4]	$792,000	$1,195,000
Construction Management [5]	$939,000	$1,352,000
Total First Cost	$14,352,000	$22,198,000

[1] For the Locally Preferred Plan, $14,000 of land and damage cost is assigned to recreation – see Table 15 cost apportionment.

[2] For the Locally Preferred Plan (LPP), the cost of this item includes Gateway access ($476,000) and Park Road Bridge ($3,304,000) – both assigned to recreation; and $56,000 for observation decks was assigned to restoration. All these items are cost shared at 100% local cost. (see Table 15)

[3] For both the NER and LPP, $381,000 was assigned to restoration for the upgrade of the recreation trail to allow vehicular access for operation and maintenance. The LPP also includes $132,000 for the soft trail ($83,500) and parking ($48,500) in Tandy Hills – see Tables 14 and 15 for a summary of the cost apportionment.

[4] For the NER plan, $92,000 is apportioned to utility relocations, $631,000 to restoration, and $69,000 to recreation. For the LPP, $92,000 is apportioned to utility relocations, $472,000 for recreation ($69,000 to trails and $403,000 for access and bridge relocation), $631,000 to restoration – see Tables14 and 15 for a summary of the cost apportionment.

[5] For the NER plan $79,000 is apportioned to utility relocations, $775,000 to restoration, and $85,000 to recreation. For the LPP, $79,000 is apportioned to utility relocations, $796,000 to restoration, and $477,000 to recreation – see Tables 14 and 15 for a summary of the cost apportionment.

Table 19 displays the equivalent annual costs and benefits of the NER plan for both restoration and recreation components.

Table 19
Equivalent Annual Costs and Benefits – NER Plan
(October 2002 price level, 50-Year Period Analysis, 5.875% Discount Rate)

Costs and Benefits	Restoration	Recreation	TOTALS
First Costs:			
First Costs	$13,355,000	$997,000	$14,352,000.00
Interest During Construction	$1,212,000	$29,000	$1,241,000.00
Total Investment Cost	$14,567,000	$1,026,000	$15,593,000.00
Annual Costs:			
Interest and Amortization of Initial Investment	$908,100	$64,000	$972,100.00
OMRR&R (average)	$61,000	$15,000	$76,000.00
Total Average Annual Cost	$969,100	$79,000	$1,048,100.00
Annual Restoration Benefits:			
Recreation		$805,100	
As Average Annual Habitat Units	421.45		
Recreation Benefit Cost Ratio	10		

Tables 20 and 21 display the Federal and non-Federal cost apportionments for the NER and LPP/Recommended plans, respectively.

Table 20
Cost Apportionment – NER Plan (October 2002 price level)

Item	Restoration Costs	Recreation Costs	Total Cost
First Costs	$13,355,000	$997,000	$14,352,000
Federal Share	$8,680,000	$498,500	$9,178,500
Non-Federal Share	$4,675,000	$498,500	$5,173,500
Non-Federal Share Summary:			
Lands and Damages	$3,306,000	$0	$3,306,000
Utility Relocations [1]	$959,000	$0	$959,000
Cash Payment	$410,000	$498,500	$908,500
Total Non-Federal Share	$4,675,500	$498,500	$5,173,500

[1] Includes $788,000 for construction, and $171,000 in engineering, design, supervision, and administration.

Table 21
Cost Apportionment - Locally Preferred/Recommended Plan
(October 2002 price level)

Item	Restoration Costs	Recreation Costs	Total Cost
First Costs	$16,480,000	$5,718,000	$22,198,000
Federal Share	$8,680,000	$498,500	$9,178,500
Non-Federal Share	$7,800,000	$5,219,500	$13,019,500
Non-Federal Share Summary:			
Lands and Damages	$6,164,000	$14,000	$6,178,000
Utility Relocations [1]	$959,000	$0	$959,000
Access and Bridge Relocation [2]	$0	$4,660,000	$4,660,000
Cash Payment	$677,000	$545,500	$1,222,500
Total Non-Federal Share	$7,800,000	$5,219,500	$13,019,500

[1] Includes $788,000 for construction, and $171,000 for engineering, design, supervision, and administration.
[2] Includes $3,780,000 for construction, and $880,000 in engineering, design, supervision, and administration

OPERATIONS, MAINTENACE, REPAIR, REHABILITATION AND REPLACEMENT

The Federal Government and Tarrant Region Water District (TRWD) will enter into a project cooperation agreement (PCA) under which TRWD would accept the project following completion of construction and ensure operation, maintenance, repair, rehabilitation, and replacement (OMRR&R), in accordance with Federal regulations. The major items involved include maintaining restoration areas (native grassland buffer, native grasslands/tree mottes, reforestation plots, and wetlands), maintain the oxbow channel, including the plug opening, the Beach Street bridge, and the in-channel weir, and maintenance of the access trails, both concrete and crushed aggregate, as well as the parking lots and restroom facilities. An operations and maintenance manual would be prepared by the Fort Worth District after completion of the project, and periodic inspections would be conducted to ensure that all required maintenance is being performed. Table 22 summarizes the OMRR&R costs.

Table 22
Breakdown of OMRR&R Costs
(October 2002 Price Levels)

Ecosystem Restoration:	
Wetland maintenance	**$12,500**
Water Supply	**$12,500**
Riparian Forest/stringers	**$18,000**
Native Grassland	**$10,000**
Oxbow Channel maintenance	**$16,000**
Access	**$3500**
Total–Ecosystem Restoration	**$72,500**
Recreation	
Access	**$4,000**
Observation Decks	**$2,000**
Parking Lot	**$1,000**
Restroom	**$8,000**
Total—Recreation	**$15,000**
Total OMRR&R	**$87,500**

NON-FEDERAL RESPONSIBILITES

Prior to commencement of construction, local interests must agree to meet the requirements for non-Federal responsibilities, as summarized below and in future legal documents. The final non-Federal responsibilities will be detailed in the PCA. In addition, a Reconstruction Engineering and Design (PED) will be executed for the project prior to preparation of plans and specifications.

a. Provide 35 percent of the separable project costs allocated to environmental restoration and 50 percent of the separable project costs allocated to recreation, as further specified below:

(1) Enter into an agreement, which provides, prior to execution of a project cooperation agreement for the project, 25 percent of design costs.

(2) Provide, during construction, any additional funds needed to cover the non-federal share of design costs.

(3) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project.

(4) Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project.

(5) Provide, during construction, any additional costs as necessary to make its total contribution equal to 35 percent of the separable project costs allocated to environmental restoration and 50 percent of the separable project costs allocated to recreation.

b. Provide 100 percent of the costs of construction of the locally preferred plan (LPP), which are in excess of the costs of construction of the national ecosystem restoration (NER) plan.

c. Provide 100 percent of the cost of all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas for the LPP, and perform or assure the performance of all relocations determined by the Federal Government, after consultation with the city, to be necessary for the construction, operation, and maintenance of the LPP.

d. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, including mitigation features, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and any specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

e. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

f. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the

construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

g. Hold and save the Government free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.

h. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

i. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

j. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

k. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project and otherwise perform its obligations in a manner that will not cause liability to arise under CERCLA.

l. Prevent future encroachments on project lands, easements, and rights-of-way, which might interfere with the proper functioning of the project.

m. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

n. Comply with all applicable Federal and State laws and regulations, including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

o. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the

total amount authorized to be appropriated for the project, in accordance with cost sharing provisions of the project cooperation agreement;

p. Not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

q. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

r. Obtain all necessary water rights for the operation of the project.

FINANCIAL ANALYSIS

Financial Commitment. Table 23 displays a summary of the total financial obligation of the non-Federal sponsor(s) over the life of the project. The total financial obligation of the non-Federal partner(s) during project implementation is estimated at $9,240,500; the annual non-Federal obligation for operation, maintenance, repair, rehabilitation, and replacement is estimated at $76,000 at the current price level. Table 24 displays their financial obligation by fiscal year.

Table 23
Summary of Non-Federal Sponsor Financial Obligation

Total Project Cost – Recommended Plan	$	22,198,000
Total Federal Share	$	9,178,500
Total Non-Federal Share:		
Total Lands and Damages	$	6,178,000
Net Lands Currently Owned / Donated[(1)]	$	(3,779,000)
Financial Cost of Land to be Acquired	$	2,399,000
Relocations	$	5,619,000
Cash	$	1,222,500
Total Financial Obligation (Implementation)	$	9,240,500
Total Annual OMRR&R [(2)]	$	76,000

[(1)] Land currently owned by TRWD and donated by the city of Fort Worth.
[(2)] Operation, maintenance, repair, rehabilitation, and replacement

Table 24
Schedule of Federal and Non-Federal Expenditures

	Federal	Non-Federal		
	Cash	Cash	Lands/Relocations	Total
Implementation				
FY 2003	$ 300,000	$ 100,000	$ 0	$100,000
FY 2004	$ 1,350,000	$ 395,000	$ 1,500,000	$1,895,000
FY 2005	$ 2,000,000	$ 0	$ 3,400,000	$3,400,000
FY 2006	$ 2,000,000	$ 240,000	$ 3,118,000	$3,358,000
FY 2007	$ 2,000,000	$ 240,000	$ 0	$240,000
FY 2008	$ 1,528,500	$ 247,500	$ 0	$247,500
Total	$ 9,178,500	$ 1,222,500	$ 8,018,000	$9,240,500

Statement of Financial Capability. The statement of financial capability is based on information provided by the Tarrant Regional Water District (TRWD), and is a description of its capability to meet its financial obligations for the recommended plan. The TRWD is a political subdivision of the State of Texas formed in 1924 with the purpose of water supply and flood control. One of the largest raw water suppliers in the state, TRWD serves over 30 wholesale customers (over 1.5 million users), including Fort Worth, Arlington, Mansfield, and the Trinity River Authority of Texas. TRWD owns and maintains four reservoirs and utilizes three others for terminal storage, and also maintains the Fort Worth Floodway - Floodway Levee System. In addition, TRWD is involved in reclamation and construction of facilities, and has power of eminent domain, the right to sue to protect water rights, the right to transfer water rights, developing hydroelectric projects, and selling of hydroelectric rights. Cooperation with other governmental entities is permitted. Contributions by others can be tax revenue or bond proceeds.

TRWD had General Fund and Capital Projects Fund assets and other debits totaling $19,847,000 and $15, 882,000 for fiscal years (FY) 2001 and 2002 (ending September 30), respectively. These assets are comprised of government fund types (general and capital projects) as well as general fixed assets. Total liabilities for the same time periods were $2,309,000 and $1,827,000, respectively.

Within the government fund types TRWD had total revenues (from the sale of water, property taxes, land lease rentals, oil and gas royalties, sale of rock and gravel, and investment income) of $27,213,000 and $7,312,000, compared to expenditures of $9,275,000 and $14,049,000 in FY 2001 and 2002, respectively. When taking into account non-operating revenues and expenses, and retained earnings/fund balance at the beginning of the year, the retained earnings/fund balances for FY 2001 and FY2002 were $17,475,000 and $14,055,000, respectively.

Financing Plan. The financing plan decscribes TRWD capabilities to meet its financial obligation for the recommended plan. According to TRWD, they plan to fund their portion of the recommended plan including real estate acquisitions and a cash payment

using funds available from their general and capital projects funds. Together, the amount of cash and cash equivalents total $12,23533,000 and $13,136,000 in FY 2001 and 2002, respectively. TWRD is currently developing their FY 04 and beyond budgets to satisfy their financial obligation for project implementation. TRWD will annually budget and fund their operation, maintenance, repair, rehabilitation, and replacement from their general fund. The financing plan does not require the passage of a future bond election.

Assessment of Financial Capability. Based on the above review of TRWD's financial capabilities and proposed financing plan, it is reasonable to expect that TRWD has ample resources available to satisfy the non-Federal financial obligation of the recommended plan. Their balance sheet demonstrates significant assets in excess of liabilities, and their anticipated cash flow and available cash balances are more than sufficient to satisfy their financial obligations.

PUBLIC INVOLEMENT

Purpose of Program. This feasibility study focused on the development of a feasible, environmentally acceptable, publically supportable ecosystem restoration plan. Numerous meetings and conversations have been held with various entities and interested citizens to share the latest possible information and to focus this study toward investigating the most viable solutions. In addition, various public workshops/meetings were held in the study area for the citizens to give input into the problems and possible solutions, as stipulated by Public Law 99-662 and Public Law 104-303.

Participants. Study participants worked closely over a seventeen-month period in an effort to inform and involve interested citizens in the study area. The entities involved in this effort include the Fort Worth District (Corps of Engineers), city of Fort Worth, Tarrant Regional Water District, Streams and Valleys, Inc., the U.S. Fish and Wildlife Service, and Texas Parks and Wildlife Department (TPWD). Additionally, TRWD consultants, GideonToal, have participated in many of the meetings. The staff and representatives of these entities have work diligently to answer citizen questions and concerns.

Public Workshops. As part of the Trinity River Vision Master Plan work efforts, a series of over 58 public meetings were held with local citizens and local interest groups about the future of the Trinity River and its major tributaries in Fort Worth, Texas. Two public meetings were held specifically with local citizens interested in the river segment including the Riverside Oxbow area. The sign-in sheets and the minutes of those meetings are included in Appendix L, Public Review/Involvement. In addition, in approximately the same time frame as the Riverside Oxbow study, the Parks and Community Services Department of the city of Fort Worth was holding a series of public meetings with citizens interested in updating a Master Plan for the Gateway Park area. Both of these on-going public participation venues offered us the opportunity to seek public input on citizens in regards to the Riverside Oxbow project.

Public Review. The Notice of Availability of the draft report and integrated environmental assessment (EA) was mailed on April 14, 2003, to approximately 25 agencies and individuals who had indicated an interest in receiving and reviewing the document.

Comments received during the 30-day public comment period, and respective responses will be included in Appendix K.

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RIVERSIDE OXBOW
FORT WORTH, TEXAS

CHAPTER 6
DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the results of feasibility level investigations made to identify solutions to the water and related land resource problems and needs within the Riverside Oxbow, Fort Worth, Texas study area.

DISCUSSIONS

The project study area encompasses the Riverside Oxbow watershed within the city of Fort Worth, Texas.

The primary planning objective for this feasibility level investigation was to determine the most economically feasible plan to restore the ecosystem along the oxbow, which would also be supportable by the local residents and sponsor. Cooperation between the city, TRWD, Streams and Valleys, Inc., and the Corps led to the adoption of restoration criteria.

The National Ecosystem Restoration (NER) Plan consists of reestablishing flows through the old West Fork of the Trinity River oxbow including replacing the existing Beach Street Bridge; creation of 69.6 acres of emergent wetlands, open water, and vegetative fringe habitat; habitat improvement of 179.7 acres of existing forested areas, including establishment of a 150 foot wide riparian buffer along the West Fork from Riverside Drive to East 1st Street; establishment of a buffer of native grasses and forbs on approximately 45.6 acres of land; reforestation of roughly 66.9 acres using a variety of native hard and soft mast trees and shrubs; and preservation and habitat improvements to approximately 206.9 acres of native floodplain grassland. The NER Plan also includes compatible linear recreation along a 9,000-feet by 10-feet wide concrete trail including one vehicular bridge, 1,400 feet of crushed agregate trail, 7,600 feet of wood mulch equestrian trail, and other associated facilities (access points, parking lot, and restroom facilities).

The estimated first cost of the NER plan is $13, 355,000 with a Federal and non-Federal share of $8,680,000 and $4,675,000 respectively. The NER would produce approximately 301.61 average annual habitat units (AAHUs) at a cost of approximately $3,213/AAHU. The estimated first cost of the recreation components of the NER is $997,000 with a Federal and non-Federal share of $498,500 and $498,500 respectively. The average annual cost and benefit for these recreation components are $78,961 and $805,100 respectively with net benefits of $726,139 and a benefit-to-cost ration of 10 to 1.

The NER Plan was viewed by the Tarrant Regional Water District (TRWD), the local sponsor, as a step toward implementation of a long-range master plan for the overall Clear Fork and West Fork of the Trinity River system within Tarrant County. In addition, several locally preferred features, as described below, were desired by the TRWD to further address requirements of their long-range master plan. As a result, they selected a Locally Preferred Plan.

The LPP would consist of the NER plan features along with the several additional features, which includes eradication of 80 acres of invasive species and reestablishment of native species and creek bed protection on 112 acres within the Tandy Hills Nature Preserve, which is located on the south side of IH-30. The LPP also includes linear recreation in the form of 7,743 feet of crushed agregate trail and associated facilities (access points and parking lot) in the Tandy Hill Nature Preserve; three observation areas on the lands associated with the NER plan; and a new Gateway Park entrance road and bridge. These additional features of the LPP would be funded entirely by the non-Federal sponsor. The estimated non-Federal first cost of the additional local features is $7,846,000.

The Recommended Plan is the LPP. In total, the recommended plan would restore ecosystem values on 512.2 acres of floodplain lands, approximately 2 miles of Oxbow river channel, 56.5 acres of wetlands, and 112 acres of uplands. It would also provide 25,700 feet of mixed surface linear recreation trails. The estimated first cost for construction of the recommended LPP project is $22,198,000, with a Federal cost of $9,178,500 and a non-Federal cost of $13,019,500.

The Recommended Plan is the Locally Preferred Plan (LPP), which is a combination of the National Ecosystem Restoration (NER) Plan and Additional Local Features (ALF), which would be funded entirely by the non-Federal sponsor (Tarrant Regional Water District). The total financial cost of the Recommended Plan would be approximately $22,198,000. The total economic cost used to evaluate benefit-cost ratios would be approximately $997,000, in the NER plan. Annual net benefits for the recreation features would total $805,100, yielding a BCR of 10.0, excluding the costs and benefits of the additional recreation features associated with the LPP. Ecosystem restoration benefits which are measured in non-monetary terms would yield gains of 376.05 average annual habitat units (AAHU) over future without project conditions. The total first cost for the recommended plan would be $22,198,000.

CONCLUSIONS

The following conclusions are based on the study findings conducted in connection with this feasibility level report:

a. A significant need for implementation of ecosystem restoration measures and construction of recreation facilities to meet the identified needs of these project purposes.

b. The Recommended Plan is a multi-objective project, which would consist of ecosystem restoration features and recreation amenities.

c. The Tarrant Regional Water District was identified as the local sponsor for construction of the project. Federal and non-Federal cost apportionments for the Recommended Plan were estimated at $9,178,500 (41.3%) Federal and $13,019,500 (58.7%) non-Federal.

d. The Recommended Plan will cause no significant environmental impacts within the study area. A draft Finding of No Significant Impact (FONSI) has been prepared and is included herein. Distribution of this report, including the draft FONSI, was made to the public for review and comment on April 14, 2003.

e. Further evaluation, including Value Engineering (VE) studies, will be conducted on the ecosystem restoration and recreation features in the pre-construction, engineering and design phase. The results of these studies may alter the project materials, design, costs, and cost apportionment or amount of Federal participation in the project.

RECOMMENDATIONS

I recommend that the ecosystem restoration and recreation features identified in the Recommended Plan for the Riverside Oxbow, Arlington, study area be authorized for construction in accordance with the cost sharing provisions set forth in this report.

This recommendation is made with the provision that prior to project implementation, the non-Federal sponsor shall enter into a binding agreement with the Secretary of the Army to perform the items of local cooperation, as specified in Chapter 5 of this document.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent to the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

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Robert P. Morris, Jr.
Lt. Colonel, Corps of Engineers
District Engineer

LIST OF PREPARERS

The people who were primarily responsible for contributing to the preparation of this Interim Feasibility Report and Integrated Environmental Assessment are listed in Table 25.

Table 25
List of Preparers

NAME	DISCIPLINE/ EXPERTISE	EXPERIENCE	ROLE IN DOCUMENT
Marcia R. Hackett	Biologist	6 years, Corps of Engineers	Project Management
Billy K. Colbert	Environmental Resource Planner	15 years Corps of Engineers; 15 years U.S.F.W.S.	Report - EA Preparation
Dennis C. Akins	GIS Specialist	3 years Corps of Engineers	EA Preparation
Wayne C. Elliott	Environmental Design	8 years, Corps of Engineers	HTRW Analysis
Jay R. Newman	Cultural Resources	13 years, Corps of Engineers	Report - EA Preparation; SHPO Concurrence
Jeffrey G. Comer	Civil Engineer	23 years, Corps of Engineers	Civil Design
Warren D. Shaver	Civil Engineer	35 years, Corps of Engineers	Structural Design
Craig H. Loftin	Hydraulic Engineer	22 years, Corps of Engineers	Hydrologic and Hydraulic Analysis
Michael A. Danella	Hydraulic Engineer	20 years, Corps of Engineers	Hydrologic and Hydraulic Analysis
Thomas R. Hendricks	Realty Specialist	16 years, Corps of Engineers	Real Estate
Douglas P. Massoth	Geotechnical Engineer	18 years, Corps of Engineers	Geotechnical Design
Eric J. Irwin	Landscape Architect	11 years, Corps of Engineers	Recreation Planner
James H. Sears	Cost Estimating	49 years, Corps of Engineers	Cost Estimating
Richard A. Keene	Cost Estimating	28 years, Corps of Engineers	Preparation - MCACES Cost Estimate

FINDING OF NO SIGNIFICANT IMPACT

UPPER TRINITY RIVER BASIN, TEXAS
RIVERSIDE OXBOW, FORT WORTH

At the request of Tarrant Regional Water District, and under authority of an April 22, 1988 resolution by the United States Senate Committee on Environmental and Public Works, the Fort Worth District Corps of Engineers conducted a study to identify water and water related land resource needs of the Riverside Oxbow study area of the Trinity River within the city limits of Fort Worth, Texas.

Investigations included examination of various ecosystem restoration measures within the floodplain of the West Fork of the Trinity River in eastern Fort Worth, Texas, along with restoration measures in adjacent riparian stringers and native prairie. Eleven alternative plans were formulated that led to the identification of the National Ecosystem Restoration (NER) Plan. In addition a "No Action" alternative and a Locally Preferred Plan were carried to the final array of alternatives.

The NER Plan consists of reestablishing low flows through the old West Fork of the Trinity River oxbow including replacing the existing Beach Street Bridge; creation of 69.6 acres of emergent wetlands, open water, and vegetative fringe habitat; and habitat improvement of 179.7 acres of existing forested tracts, including establishment of a 150 foot wide riparian buffer along the West Fork from Riverside Drive to East 1st Street. The buffer would consist of grass and forbs established on approximately 45.6 acres of land. Additional features of the NER include reforestation of approximately 66.9 acres of land using a variety of native hard- and soft-mast trees and shrubs and preservation and habitat improvements to approximately 206.9 acres of native prairie and scrub/shrub uplands. The NER Plan also includes compatible linear recreation development along a 9,000 foot-long by 10 foot-wide concrete trail, one vehicular bridge, 1,400 feet of crushed agregate trail, 7,600 feet of wood mulch equestrian trail, and associated facilities (access points, parking lot, and restroom facilities).

Tarrant Regional Water District, as the local sponsor for this study, selected a Locally Preferred Plan (LPP) that differs from the NER Plan. The LPP consists of the NER features along with the additional features of reestablishing native species and protecting creek beds on 112 acres within the Tandy Hills Nature Preserve and adjacent private lands, located on the south side of IH-30, and eradicating invasive species on 80 of those 112 acres; 7,700 feet of crushed agregate trail and associated facilities (access points and parking lot) in the Tandy Hill Nature Preserve; construction of three observation areas on lands associated with the NER plan; and construction of a new Gateway Park entrance road and bridge. These additional features would be funded by the non-federal sponsor.

The LPP is the Recommended Plan. It would provide for ecosystem restoration on 568.7 acres of floodplain lands, approximately 2 miles of Oxbow river channel, 69.6 acres of wetlands, and112 acres of riparian stringer and adjacent upland native grasses. It would also include 25,700 feet of compatible mixed surface linear recreation trails.

The Recommended Plan has been reviewed in accordance with Section 404 of the Clean Water Act. All features proposed would comply with the terms and conditions of Nationwide permit 27, Stream and Wetland Restoration Activities. The State of Texas has reviewed and provided water quality certification for Nationwide permit 27 and no further evaluation of Section 404 of the Clean Water Act is necessary. The proposed project was also reviewed and found to be in compliance with Section 10 of the Rivers and Harbors Act.

Executive Order 11988, Floodplain Management, was considered during the development of the Recommended Plan. There are no practical alternatives to achieve the project purposes of ecosystem restoration and recreation trail development without placing fill within the floodplain. Material removed from the project area requiring disposal as part of the recommended plan would be placed in approved landfills for the types of materials involved. The proposed fill actions would not result in adverse environmental impacts and, further, floodplain fill for recreational trail and ecosystem restoration would not directly or indirectly induce additional development in the floodplain and would, therefore, be in compliance with Executive Order 11988. Executive Order 11990 on the Protection of Wetlands was also considered during the development of the proposed project. The proposed project would neither adversely impact nor result in any loss of wetland areas so the project is in compliance with Executive Order 11990. The recommended plan was also found to be in compliance with the Executive Order on Environmental Justice.

Cultural resources compliance issues for the Riverside Oxbow study have been addressed through consultation with the Texas State Historic Preservation Office (SHPO) in accordance with Section 106 of the National Historic Preservation Act. On site investigations resulted in the identification of historic archeological properties that could be

impacted by excavation of the proposed return channel from the Oxbow Center Zone wetlands. As a result of that finding, the channel's alignment was modified to avoid those historic properties. The SHPO has tentatively concurred with the Corps' proposal to survey the modified alignment prior to construction so that final adjustments can be made as required to avoid any undiscovered historic properties.

Review by the U.S. Fish and Wildlife Service supports the Recommended Plan and has determined that the proposed project is not likely to adversely affect threatened or endangered species.

An Environmental Assessment has been made of the Recommended Plan and its alternatives. Based upon the Environmental Assessment and results of coordination, I have concluded that the recommended plan will not have a significant adverse effect on the human environment nor is it environmentally controversial. In addition, construction of the project will not constitute a major Federal action of sufficient magnitude to warrant preparation of an Environmental Impact Statement.

DATE_____

Robert P. Morris, Jr.
Lieutenant Colonel, Corps of Engineers
Deputy District Engineer